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BULLETIN No. 85.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
A. C. TRUE, Director.

A REPORT OF INVESTIGATIONS

ON

The Digestibility and Nutritive Value of Bread.

BY

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DIRECTOR,
AND
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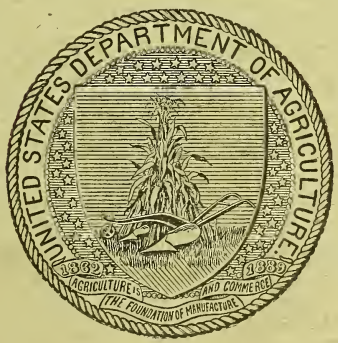

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1900.

LIST OF PUBLICATIONS OF THE OFFICE OF EXPERIMENT STATIONS ON THE FOOD AND NUTRITION OF MAN.

NOTE.—For those publications to which a price is affixed application should be made to the Superintendent of Documents, Union Building, Washington, D. C., the officer designated by law to sell Government publications.

Charts. Food and Diet. By W. O. Atwater. (Four charts, 26 by 40 inches.) Price per set, unmounted, 75 cents.

Bul. 21. Methods and Results of Investigations on the Chemistry and Economy of Food. By W. O. Atwater. Pp. 222. Price, 15 cents.

Bul. 28. (Revised edition.) The Chemical Composition of American Food Materials. By W. O. Atwater and A. P. Bryant. Pp. 87. Price, 5 cents.

Bul. 29. Dietary Studies at the University of Tennessee in 1895. By C. E. Wait, with comments by W. O. Atwater and C. D. Woods. Pp. 45. Price, 5 cents.

Bul. 31. Dietary Studies at the University of Missouri in 1895, and Data Relating to Bread and Meat Consumption in Missouri. By H. B. Gibson, S. Calvert, and D. W. May, with comments by W. O. Atwater and C. D. Woods. Pp. 24. Price, 5 cents.

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Bul. 43. Losses in Boiling Vegetables and the Composition and Digestibility of Potatoes and Eggs. By H. Snyder, A. J. Frisby, and A. P. Bryant. Pp. 31. Price, 5 cents.

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Bul. 45. A Digest of Metabolism Experiments in which the Balance of Income and Outgo was Determined. By W. O. Atwater and C. F. Langworthy. Pp. 434. Price, 25 cents.

Bul. 46. Dietary Studies in New York City in 1895 and 1896. By W. O. Atwater and C. D. Woods. Pp. 117. Price, 10 cents.

Bul. 52. Nutrition Investigations in Pittsburg, Pa., 1894–1896. By Isabel Bevier. Pp. 48. Price, 5 cents.

Bul. 53. Nutrition Investigations at the University of Tennessee in 1896 and 1897. By C. E. Wait. Pp. 46. Price, 5 cents.

Bul. 54. Nutrition Investigations in New Mexico in 1897. By A. Goss. Pp. 20. Price, 5 cents.

[Continued on third page of cover.]

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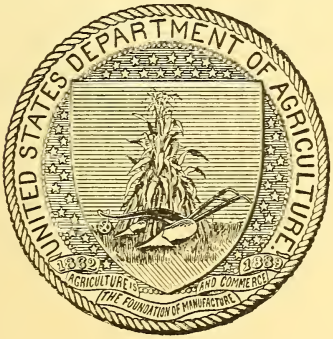

WASHINGTON:
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1900.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., April 20, 1900.

Sir: I have the honor to transmit herewith a report of investigations on the digestibility and nutritive value of bread, conducted at the Maine Agricultural Experiment Station by Chas. D. Woods, director of the station, and L. H. Merrill, the station chemist, under the supervision of Prof. W. O. Atwater, special agent in charge of nutrition investigations, in accordance with instructions given by the Director of this Office.

In connection with the nutrition investigations under the general direction of this Office, studies on bread, with special reference to digestibility, methods of making and baking, and other factors affecting its nutritive value, have been carried on at several institutions by a number of investigators, Professor Woods, as special agent of the Department, having had the immediate direction of this work. The investigations herein reported are a part of this series and have to do with the digestibility of various kinds of bread when eaten alone and when forming the principal part of a simple mixed diet, the determination of the amount of metabolic nitrogen in feces, the digestibility of bread of different sorts by artificial methods, the comparative value of bread made with skim milk and with water, and the losses in bread making. On some of these subjects the work is being continued and the data here given constitute a progress report.

The report is transmitted with the recommendation that it be published as Bulletin No. 85 of this Office.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	7
Analytical methods	8
Heat of combustion	8
Composition of food materials	9
Composition of feces	10
Experiments on the digestibility of bread	11
Digestion experiments with men	11
Experiments with bread alone	13
Experiments with mixed diet, largely bread	15
Metabolic products in feces	33
Treatment of feces with pepsin solution	34
Treatment of feces with ether, alcohol, hot water, and cold limewater	35
Metabolic nitrogen in the feces on a carbohydrate diet and during fasting	39
Artificial digestion of bread with pepsin	42
Comparison of coefficients of digestibility of protein in bread as determined by different methods	43
Skim milk versus water in bread making	45
The digestibility in pepsin solution of bread made with skim milk and with water	48
Losses in bread making	49

DIGESTIBILITY AND NUTRITIVE VALUE OF BREAD.

INTRODUCTION.

Wheat, in one or another of its many preparations for the table, forms a very large factor in the nutrition of the American people. In connection with the investigations of the food and nutrition of man which have been carried on in cooperation with the Office of Experiment Stations of the U. S. Department of Agriculture for the past few years, the Maine Experiment Station has been investigating the digestibility and nutritive value of bread. While this subject has been investigated from time to time, particularly in Europe, with very interesting and valuable results, few of these results are applicable to the conditions common in this country. The European investigations have been made with flours different from those in common use in the United States and the breads have been made by methods not commonly adopted by bakers in this country.

A considerable number of foreign investigations on the digestibility of bread or other foods made from the cereal grains and experiments on bread and other similar diets in which the balance of income or outgo of nitrogen was determined have been summarized in previous publications of this Office.[1] A number of special studies of bread have been made in connection with the nutrition investigations conducted under the auspices of the Office of Experiment Stations and reported in earlier bulletins.[2] The studies here reported are only part of an investigation undertaken with the hope of accumulating data which shall serve to answer the numerous questions arising as to the effects of milling upon the nutritive value of the resulting flours. The purpose of this bulletin is simply to put on record the results of some of the investigations. Discussion is reserved until the results of the more extended investigations now being carried on shall be available.

The work here reported includes (1) 24 digestion experiments with men, in which bread formed all or the main part of the diet; (2) 24 experiments upon the artificial digestion of bread with pepsin; (3) a

[1] U. S. Dept. Agr., Office of Experiment Stations, Buls. 21 and 45.

[2] U. S. Dept. Agr., Office of Experiment Stations, Buls. 31, 35, 52, 53, and 67.

study of the income and outgo of nitrogen in 26 experiments with men; (4) the estimation of metabolic nitrogen in the feces from the 24 digestion experiments with men; (5) a study of metabolic nitrogen in feces in a period with a diet of carbohydrates alone, in a period of fasting, and in a period of partial fasting; (6) an investigation of the nutritive value of bread made with skim milk as compared with that made with water, and (7) experiments on the losses of material in baking bread.

ANALYTICAL METHODS.

All food materials used in the investigation were sampled at the time of use and all the feces were collected, dried, and analyzed. The methods of analysis were mainly those of the Association of Official Agricultural Chemists.[1] In determining the ash in flour and bread, it was found necessary to extract the charred parts with hot water before the incineration could be completed. In preparing the bread for analysis, it was sliced and dried at a temperature of about 60°. The feces were dried at a like temperature. The determination of ether extract in the feces was accomplished with considerable difficulty and the results are not regarded as wholly satisfactory. Composite samples of milk used during each experiment were taken for analysis. In the first four experiments in which no food other than bread was eaten, a small amount of beef tea was allowed each subject, but the nitrogen thus taken was not determined, as it was believed that it would be wholly absorbed from the intestines and appear largely unchanged in the urine.[2]

HEAT OF COMBUSTION.

The determinations of the heat of combustion of food, feces, and urine were made by burning samples of dried material in the bomb calorimeter in the usual manner. The milk and urine were prepared for combustion in the following manner: A weighed absorption block[3] of cellulose, previously dried for two days over sulphuric acid, was placed in a platinum capsule and saturated with a known amount of milk or urine. The capsule and block were then placed in a drying oven and dried at a temperature not exceeding 70° C., after which the absorption block was again saturated with a known amount of substance and again dried. The combustion was made in the usual manner, correction being made for the heat given off by the combustion of the absorption block itself. This latter factor was previously ascertained by determining the heat of combustion of the cellulose absorption blocks.

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[1] U. S. Dept. Agr., Division of Chemistry Bul. 46.

[2] U. S. Dept. Agr., Office of Experiment Stations Bul. 66.

[3] Described by Kellner, Landw. Vers. Stat., 47 (1896) p. 297.

COMPOSITION OF FOOD MATERIALS.

The different kinds of bread were handmade from ordinary wheat flour, so-called Graham flour, true Graham flour, and entire wheat flour. The milk and butter were the ordinary dairy products of good quality. The analyses of the food materials are summarized in Tables 1 and 2:

TABLE 1.—*Percentage composition and heat of combustion per gram of fresh food materials.*

Laboratory number.	Number of experiment.	Material.	Water.	Nitrogen.	Protein.	Fat.	Carbohydrates.	Ash.	Heat of combustion. Determined.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
6001	123	White bread	36.06	1.40	8.78	1.73	52.73	0.70	2,841
6002	124	do	34.48	1.39	8.68	1.68	54.42	.74	2,938
6003	125	do	34.68	1.39	8.68	1.91	53.43	1.30	2,926
6004	126	do	34.10	1.40	8.73	1.74	54.04	1.39	2,938
6005	127	do	34.07	1.36	8.51	2.98	52.46	1.98	2,943
6006	128	do	33.35	1.37	8.59	2.23	53.90	1.93	2,960
6007	129, 130	do	38.51	1.52	9.50	.81	50.42	.76	2,698
6034	131	Graham bread	28.17	1.62	10.11	1.28	57.42	3.02	3,032
6035	132	do	41.92	1.32	8.24	1.05	46.85	1.94	2,476
6036	133	do	51.81	1.08	6.76	.90	38.61	1.92	2,049
6037	134	do	42.39	1.26	7.86	1.16	46.55	2.04	2,456
6047	135	Entire wheat bread	42.22	1.35	8.45	.42	47.07	1.84	2,467
6048	136	do	40.11	1.40	8.77	.42	48.79	1.91	2,560
6049	137	do	40.39	1.39	8.67	.43	48.62	1.89	2,558
6064	138	White bread	38.04	1.45	9.07	1.95	49.65	1.29	2,818
6065	139	do	37.43	1.47	9.19	1.87	50.22	1.29	2,840
6077	140	do	37.35	1.44	8.97	2.39	49.94	1.35	2,845
6078	141	do	37.61	1.43	8.96	2.29	49.65	1.49	2,829
6086	142	Entire wheat bread	38.34	1.51	9.43	2.62	48.21	1.40	2,859
6087	143	do	38.83	1.49	9.29	2.68	47.83	1.37	2,829
6097	144	Graham bread	42.09	1.14	7.15	2.97	46.21	1.58	2,639
6098	145	do	41.90	1.19	7.42	2.75	46.46	1.47	2,648
6120	146	White bread	38.14	1.45	9.04	1.34	50.33	1.15	2,809
6008	127	Milk	86.87	.49	3.06	3.70	5.60	.77	792
6009	128	do	86.87	.55	3.44	4.00	4.93	.76	799
6010	129	do	86.87	.53	3.31	4.00	5.02	.80	780
6011	130	do	86.52	.53	3.31	4.25	5.16	.76	807
6032	131–134	do	86.45	.55	3.44	4.00	5.38	.73	823
6033	131–134	do	86.07	.53	3.31	3.95	5.93	.74	819
6046	135–137	do	86.39	.55	3.44	4.15	5.30	.72	820
6057	135–137	do	86.43	.55	3.44	4.00	5.34	.79	812
6066	138, 139	do	87.20	.56	3.50	4.20	4.41	.69	728
6068	138, 139	do	86.81	.59	3.69	4.20	4.60	.70	799
6071	138, 139	do	86.72	.56	3.50	4.20	4.88	.70	752
6079	140, 141	do	86.38	.53	3.31	4.25	5.56	.50	797
6080	140, 141	do	86.84	.57	3.56	3.98	5.08	.54	774
6088	142, 143	do	85.51	.59	3.69	5.00	5.15	.65	902
6089	142, 143	do	86.02	.57	3.56	5.00	4.84	.58	857
6099	144, 145	do	86.07	.58	3.63	4.60	4.95	.75	888
6100	144, 145	do	86.88	.54	3.38	4.60	4.52	.62	814
6121	146	do	85.55	.58	3.63	5.40	4.67	.75	898
6067	138, 139	Butter	9.93	.21	1.31	85.00	.....	3.76	*a* 7,977
6081	140, 141	do	11.44	.22	1.38	82.45	.....	4.73	*a* 7,744
6090	142, 143	do	13.04	.13	.81	80.19	.....	5.96	*a* 7,502
6107	144, 145	do	13.26	.18	1.13	79.12	.....	6.48	*a* 7,420
6122	146	do	13.20	.20	1.25	81.48	.....	4.07	*a* 7,646

a Computed, using the factors 5.5 for protein and 9.3 for fat.

TABLE 2.—*Percentage composition and heat of combustion per gram of dry matter of different breads eaten.*

Laboratory number.	Number of experiment.	Material.	Nitrogen.	Protein.	Fat.	Carbohydrates.	Ash.	Heat of combustion. Determined.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
6001	123	White bread	2.20	13.73	2.70	82.48	1.09	4,444
6002	124	do	2.12	13.25	2.57	83.05	1.13	4,484
6003	125	do	2.13	13.29	2.92	81.80	1.99	4,480
6004	126	do	2.12	13.24	2.64	82.01	2.11	4,457
6005	127	do	2.07	12.91	4.51	79.57	3.01	4,463
6006	128	do	2.06	12.89	3.34	80.88	2.89	4,441
6007	129,130	do	2.47	15.46	1.31	82.00	1.23	4,339
6034	131	Graham bread	2.25	14.07	1.79	79.94	4.20	4,221
6035	132	do	2.27	14.20	1.81	80.66	3.33	4,263
6036	133	do	2.24	14.03	1.85	80.14	3.98	4,253
6037	134	do	2.18	13.64	2.01	80.80	3.55	4,264
6047	135	Entire wheat bread	2.34	14.61	.73	81.47	3.19	4,281
6048	136	do	2.34	14.61	.73	81.47	3.19	4,275
6049	137	do	2.34	14.61	.73	81.47	3.19	4,266
6064	138	White bread	2.34	14.64	3.15	80.13	2.08	4,548
6065	139	do	2.35	14.68	2.99	80.26	2.07	4,538
6077	140	do	2.29	14.32	3.82	79.70	2.16	4,541
6078	141	do	2.30	14.36	3.67	79.58	2.39	4,533
6086	142	Entire wheat bread	2.45	15.30	4.24	78.17	2.29	4,636
6087	143	do	2.43	15.18	4.38	78.20	2.24	4,625
6097	144	Graham bread	1.98	12.35	5.14	79.77	2.74	4,662
6098	145	do	2.04	12.77	4.73	79.96	2.54	4,557
6120	146	White bread	2.34	14.61	2.17	81.36	1.86	4,816

COMPOSITION OF FECES.

As stated above, the usual methods were followed in the analyses of the feces.

The composition of the feces in the various digestion experiments reported in this bulletin is shown in Table 3. The results are calculated to the water-free basis, since the amount of water in the fresh feces has no bearing upon the results of the digestion experiments.

TABLE 3.—*Percentage composition and heat of combustion per gram of dry matter of feces.*

Laboratory number.	Number of experiment.	Material.	Nitrogen.	Protein.	Fat.	Carbohydrates.	Ash.	Heat of combustion. Determined.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
6020	123	Feces	5.35	33.47	12.86	37.26	16.41	6,074
6021	124	do	8.57	53.67	17.70	18.29	10.34	5,950
6022	125	do	5.96	37.22	14.25	28.32	20.21	5,361
6023	126	do	8.83	55.16	14.69	18.37	11.78	5,900
6024	127	do	6.35	39.69	20.04	25.89	14.38	5,800
6025	128	do	4.82	30.14	17.38	29.97	22.51	5,611
6026	129	do	5.27	32.91	12.51	32.86	21.72	5,563
6027	130	do	5.27	32.93	23.62	22.46	20.99	5,424
6042	131	do	4.11	25.69	7.74	49.15	17.42	5,220
6043	132	do	4.24	26.52	9.95	44.53	19.00	4,613
6044	133	do	3.74	23.40	7.95	48.19	20.46	4,890
6045	134	do	4.07	25.44	8.54	44.56	21.46	4,654
6051	135	do	5.10	31.88	12.86	35.35	19.91	5,400
6052	135	do	4.10	25.64	8.52	39.42	26.42	4,340
6053	136	do	4.47	27.91	10.25	38.18	23.66	4,736
6069	137	do	4.40	27.52	16.87	31.70	23.91	5,753
6070	138	do	4.87	30.45	27.42	25.40	16.73	6,019
6082	139	do	3.94	24.65	12.95	36.17	26.23	5,604
6083	140	do	4.11	25.70	11.91	39.55	22.84	6,082
6091	141	do	4.43	27.68	15.52	38.43	18.37	5,667
6092	142	do	4.71	29.46	14.81	40.71	15.02	5,866
6103	143	do	3.40	21.23	9.14	52.29	17.34	5,035
6104	144	do	3.78	23.63	8.41	52.62	15.34	5,065
6124	145	do	3.01	18.81	12.47	43.71	25.01	5,844

EXPERIMENTS ON THE DIGESTIBILITY OF BREAD.

DIGESTION EXPERIMENTS WITH MEN.

The experiments here reported were made during the years 1896 and 1897. The subjects were young men students, with vigorous appetites and apparently normal digestion. Usually two or more experiments upon different subjects were carried on at the same time. The meals were taken in a dining room so arranged that the subjects could eat together under conditions as nearly normal as possible.

No attempt was made to limit the amount of food taken except in experiment No. 146, which was designed to show the results of partial fasting. The food of each man was kept separate. Whenever a new loaf of bread was needed it was weighed and quartered, one quarter serving as a sample for analysis. At the close of the experiment the uneaten food remaining was weighed and the amount deducted from the amount furnished. The difference was taken as the weight of the food eaten.

Each experiment was preceded by a supper of milk. Lampblack was taken in gelatin capsules with the milk, in order to facilitate the separation of the feces due to the food previous to the experiment from those of the experiment proper, which began in every case with breakfast the next morning. During the two following days the food consisted chiefly of the particular kind of bread under investigation. With the exception of the first four experiments, butter was eaten with the bread and the subjects were allowed milk and coffee, with sugar. The quantities and proportions of food were largely matters of individual selection. No attempt was made to have these the same in successive experiments. On the morning following the second day of the digestion experiment lampblack was administered in gelatin capsules with a breakfast of milk, and no solid food was taken until noon.

The separation of the feces due to the diet under investigation was easily made at the line of demarcation between the portion deeply colored by the lampblack and the lighter portion due to ordinary food. It was assumed that none of the feces from the given diet was colored by the lampblack. While it is not thought that this method of separation of the feces gives entirely satisfactory results, it seems to us at present the best available. Experiments are now being conducted which it is hoped may lead to a more satisfactory method.

In nearly all of the digestion experiments the urine was collected for the two days of bread diet, beginning with the time at which breakfast was taken. Of course it is not to be understood that the urine eliminated during this period represents the amount metabolized from the bread and other food eaten during this time. But since the urine can not be separated even as satisfactorily as the feces, and since

there are no definite data at present regarding the duration of the so-called nitrogen lag, the urine was collected simply for the time covered by the digestion experiment. The amount of nitrogen in the urine for each experiment, and in several instances the heat of combustion of the dried matter, were determined.

The details of the digestion experiments are included in the following tables. These show the kind and amount of food eaten by the subject, and in some instances the weight of the subject at the beginning and end of the experiment. The quantities in the column "total organic matter" are the sums of the quantities in the three following columns—protein, fat, and carbohydrates. The amount of protein, fat, and carbohydrates in each food material and in the feces was computed from the weight of each material multiplied by its percentage composition as shown in Tables 1 and 3. The heats of combustion shown in the last column of the tables were determined by burning the material in the bomb calorimeter and multiplying the total weight of food or feces by the heat of combustion of 1 gram as thus determined. The differences between the total nutrients in the food eaten and those rejected in the feces are taken as a measure of the total amounts digested, or, better, the amounts available for the body. The feces do not consist entirely of undigested residues, but contain a relatively large amount of metabolic products, as is explained beyond (p. 33). The amounts of nutrients rejected in the feces, while not strictly representing the undigested portion of the food, do represent approximately the amounts which are not available to the body.[1] The total amount of any particular kind of nutrient digested or available divided by the total amount of this nutrient in the food gives the percentage which is digestible or actually available to the body. These percentage values are called coefficients of digestibility or availability.

While the coefficients of digestibility of the different nutrients represent the proportion which the body actually utilizes, the corresponding value for the heat of combustion of the food does not represent the actual amount of energy which the body obtains from the food absorbed from the alimentary canal. When protein is burned in the bomb calorimeter the carbon is oxidized to carbon dioxid and the hydrogen to water. The nitrogen is left in the free state. When protein is burned in the body, however, the oxidation is not so complete. The nitrogen is excreted in the form of urea, uric acid, and other allied compounds, which also contain small amounts of carbon and hydrogen, together with some oxygen. In estimating the actual fuel values of the digestible nutrients of the food, allowance must be made for these incompletely oxidized residual products which are excreted by the kidneys. Urea is the most abundant of these excretory products,

[1] See discussion of this subject in Connecticut Storrs Sta. Rpts. 1896, p. 166, and 1897, p. 156.

and it has frequently been assumed that all of the nitrogen excreted in the urine is thus combined, and allowance is made for the heat of combustion of the amount of urea corresponding to the amount of nitrogen found in the urine. According to this last supposition 0.87 calories of the energy latent in each gram of digestible protein would be lost to the body in the urea formed from the nitrogen of the protein.[1] In a considerable number of actual determinations of the ratio of the nitrogen to heat of combustion in urine of healthy men made by Atwater and associates at Middletown, Conn., the average heat of combustion of the organic matter in the urine corresponding to 1 gram of digestible protein amounts to 1.25 calories. As a result of four determinations of the heat of combustion of the urine in the experiments here reported the factor 1.16 was obtained. Since Atwater's factor is based upon a considerably larger number of determinations, it is used in the following tables for the calculation of the energy of the digestible protein which is carried away in the unoxidized organic matter of the urine, and hence is not available to the body.

The figures given in Tables 4–27 for the proportion of energy actually available to the body in the food eaten are obtained, therefore, by deducting from the total energy of the digested food the energy lost to the body in organic matter of the urine. This latter value is determined by multiplying the total amount of digestible protein by 1.25.

In connection with the majority of the digestion experiments reported beyond, the outgo of nitrogen in the urine was determined, as explained above. Following the tabular details of each experiment is a paragraph showing the nitrogen balance in the particular instance—i. e., whether the subject gained or lost nitrogen during the two days of the test.

EXPERIMENTS WITH BREAD ALONE.

In the first four digestion experiments no food was eaten except bread. To render the diet more palatable the subjects were allowed beef tea and water ad libitum. The results of the experiments are shown in the following tables:

DIGESTION EXPERIMENT No. 123.

Kind of food.—White bread.

Subject.—H. B. S.

Weight (*without clothing*).—At beginning, 145 pounds; at end, 147 pounds.

Duration.—Two days, with six meals.

[1] Urea contains 46.67 per cent nitrogen and has a heat of combustion of 2.54 calories per gram. One gram of protein (16 per cent nitrogen) would yield (16÷46.67=) 0.342 gram urea with a heat of combustion of (2.54×0.342=)0.87. See also U. S. Dept. Agr., Office of Experiment Stations Bul. 53, pp. 27 and 28.

TABLE 4.—*Results of digestion experiment No. 123.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25.)	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6001	White bread	1,633	1,032.7	143.4	28.3	861.0	11.4	4,639
6020	Feces (water-free)	39.0	32.6	13.1	5.0	14.5	6.4	178
	Amount digested		1,000.1	130.3	23.3	846.5	5.0	4,461
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food		96.8	90.9	82.3	98.3	43.9	(96.2)
	Proportion of energy actually available to body							92.7

During this experiment the subject eliminated 2,142 grams of urine, containing 1.81 per cent or 38.8 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 11.5 grams; outgo in urine, 19.4 grams, and in feces, 1.1 grams; implying a loss of 9 grams nitrogen, corresponding to 56.3 grams protein.

DIGESTION EXPERIMENT No. 124.

Kind of food.—White bread.
Subject.—H. B. S.
Duration.—Two days, with six meals.

TABLE 5.—*Results of digestion experiment No. 124.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6002	White bread	956	619.3	83.0	16.0	520.3	7.0	2,809
6021	Feces (water-free)	31	27.8	16.6	5.5	5.7	3.2	165
	Amount digested		591.5	66.4	10.5	514.6	3.8	2,644
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food		95.5	80.0	65.6	98.9	54.3	94.1
	Proportion of energy actually available to body							91.2

During this experiment the subject eliminated 1,550 grams urine, containing 1.20 per cent or 18.6 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 6.7 grams; outgo in urine, 9.3 grams, and in feces, 1.4 grams; implying a loss of 4 grams nitrogen, corresponding to 25 grams protein.

DIGESTION EXPERIMENT No. 125.

Kind of food.—White bread.
Subject.—L. H. H.
Duration.—Two days, with six meals.

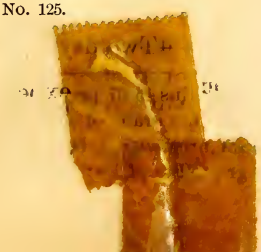

TABLE 6.—*Results of digestion experiment No. 125.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6003	White bread	1,080	691.3	93.8	20.6	576.9	14.1	3,160
6022	Feces (water-free)	47	37.5	17.5	6.7	13.3	9.5	213
	Amount digested		653.8	76.3	13.9	563.6	4.6	2,947
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food		94.6	81.7	67.5	97.7	32.6	(93.3)
	Proportion of energy actually available to body							90.3

During this experiment the subject eliminated 1,545 grams urine, containing 1.30 per cent or 20.1 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 7.5 grams; outgo in urine, 10.1 grams, and in feces, 1.4 grams; implying a loss of 4 grams nitrogen, corresponding to 25 grams protein.

DIGESTION EXPERIMENT No. 126.

Kind of food.—White bread.
Subject.—L. W. F.
Duration.—Two days, with six meals.

TABLE 7.—*Results of digestion experiment No. 126.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6004	White bread	1,069	689.5	93.3	18.6	577.6	14.9	3,141
6023	Feces (water-free)	41.7	36.8	23.0	6.1	7.7	4.9	205
	Amount digested		652.7	70.3	12.5	569.9	10.0	2,936
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food		94.7	75.4	67.2	98.7	67.1	93.5
	Proportion of energy actually available to body							90.7

During this experiment the subject eliminated 1,509 grams urine, containing 1.53 per cent or 23.1 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 7.5 grams; outgo in urine, 13.4 grams, and in feces, 1.8 grams; implying a loss of 5.9 grams nitrogen, corresponding to 36.9 grams protein.

EXPERIMENTS WITH MIXED DIET, LARGELY BREAD.

In the four digestion experiments Nos. 123–126 no other food besides bread was taken, but since it has been observed that the nutrients of a given article are more thoroughly assimilated when it is consumed with some other food than when eaten alone, in the other experiments,

Nos. 127–146, milk, butter, and sugar were allowed. In the following tables, Nos. 8–27, the results of these experiments are shown, together with the computed digestibility of the bread alone. These tables differ from those preceding in that they show the estimated feces from food other than bread, the estimated digestible nutrients in the bread, and the computed coefficients of digestibility of bread alone.

Calculated digestibility of bread alone.—In order to calculate the digestibility of the bread alone from the results obtained in the mixed diet it is necessary to assume more or less arbitrary factors for the digestibility of the food materials eaten with the bread. From a study of the results of digestion experiments made in this country and Europe it was assumed that 98 per cent of the protein, 99 per cent of the fat and 99 per cent of the carbohydrates of the milk, and 99 per cent of the fat of the butter consumed with the bread would be actually available to the body. Sugar is usually regarded as wholly digested, but when taken in considerable quantities it seems hardly probable that it is absorbed from the alimentary canal without the expenditure of some digestive juices which would be eliminated to a greater or less extent as metabolic products in the feces. In calculating the results of the experiments it is assumed, therefore, that only 98 per cent of the carbohydrates of sugar is actually available to the body. The application of these factors to the results of other experiments, as well as to those here reported, seems to show that the proportions above indicated represent approximately the percentages of digestibility for the nutrients of these food materials.

An illustration of the method of calculation may make the matter clearer. In experiment No. 127 there was a total of 151.5 grams of protein consumed in the two days, of which 56.5 came from the milk. It is assumed that 98 per cent of this protein of milk was available to the body, leaving 1.1 grams in the feces. In the total feces in this digestion experiment there was 20.5 grams of protein (N×6.25), leaving 19.4 grams as coming from the undigested or unavailable portion of the bread. The total amount of protein digested was 131 grams. The total protein in the bread eaten was 95 grams, and the estimated digestible nutrients in bread was therefore (95.0−19.4=) 75.6 grams. In order to obtain the coefficient of digestibility of the protein of the total food we divide 131 by 151.5, obtaining 86.5 per cent as the result. The estimated coefficient of digestibility of the bread alone is obtained by dividing 75.6 by 95, giving 79.6 per cent. Similar computations serve for the calculation of the digestibility of the fat and carbohydrates of the bread alone. The proportion of energy actually available to the body in the total food is obtained, as explained above, by multiplying the digestible protein (131 grams) by 1.25 and deducting the total energy thus estimated as lost in the organic matter of the urine from the energy of the food digested. In a similar manner

the digestible protein in the bread alone (75.6) multiplied by 1.25 gives the amount of energy of the bread which is eliminated in the organic matter of the urine. The percentage of total energy which is actually available to the body is then obtained by dividing the energy of the food digested (4,548 calories), less the energy lost in the urine (131×1.25=164 calories), by the energy in the total food (4,661 calories). The proportion of energy in the bread which is actually available is obtained in a like manner by dividing the difference between the estimated available energy in the bread (3,191) and the energy lost in the urine (75.6×1.25=95.0) by the total energy in the bread eaten (3,284 calories).

The details of the experiments are as follows:

DIGESTION EXPERIMENT No. 127.

Kind of food.—White bread with milk.
Subject.—L. H. H.
Duration.—Two days, with six meals.

TABLE 8.—*Results of digestion experiment No. 127.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6005	White bread	1,116.0	713.7	95.0	33.3	585.4	22.1	3,284
6008	Milk	803.3	99.3	24.6	29.7	45.0	6.2	636
6009	.....do	927.0	114.7	31.9	37.1	45.7	7.0	741
	Total		927.7	151.5	100.1	676.1	35.3	4,661
6024	Feces (water-free)	51.8	44.3	20.5	10.4	13.4	7.5	113
	Estimated feces from food other than bread		3.6	1.1	.7	1.8		20
	Estimated feces from bread		40.7	19.4	9.7	11.6		93
	Total amount digested		883.4	131.0	89.7	662.7	27.8	4,548
	Estimated digestible nutrients in bread		673.0	75.6	23.6	573.8		3,191
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food		95.2	86.5	89.6	98.0	78.8	(97.6)
	Estimated coefficients of digestibility of bread alone		94.3	79.6	70.8	98.0		(97.0)
	Proportion of energy actually available to body:							
	In total food							94.1
	In bread alone							94.3

During this experiment the subject eliminated 1,443 grams, containing 1.84 per cent or 26.6 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 12.1 grams; outgo in urine, 13.3 grams, and in feces, 1.7 grams; making a loss of 2.9 grams nitrogen, corresponding to 18.1 grams protein.

DIGESTION EXPERIMENT No. 128.

Kind of food.—White bread with milk.
Subject.—H. B. S.
Duration.—Two days, with six meals.

TABLE 9.—*Results of digestion experiment No. 128.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6006	White bread	977.0	632.3	83.9	21.8	526.6	18.9	2,892
6008	Milk	1,390.5	171.8	42.5	51.4	77.9	10.7	1,101
6009	do	1,339.0	165.7	46.1	53.6	66.0	10.2	1,070
	Total		969.8	172.5	126.8	670.5	39.8	5,063
6025	Feces (water-free)	52.6	40.7	15.9	9.1	15.7	11.9	236
	Estimated feces from food other than bread		5.8	1.8	1.1	2.9		31
	Estimated feces from bread		34.9	14.1	8.0	12.8		205
	Total amount digested		929.1	156.6	117.7	654.8	27.9	4,827
	Estimated digestible nutrients in bread		597.4	69.8	13.8	513.8		2,687
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food		95.8	90.8	92.8	97.7	70.1	(95.3)
	Estimated coefficients of digestibility of bread alone		94.5	83.2	63.1	97.6		(92.9)
	Proportion of energy actually available to body:							
	In total food							91.5
	In bread alone							89.9

During this experiment the subject eliminated 2,279 grams of urine, containing 1.23 per cent or 28 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 13.8 grams; outgo in urine, 14 grams, and in feces, 1.3 grams; making a loss of 1.5 grams nitrogen, corresponding to 9.4 grams protein.

DIGESTION EXPERIMENT No. 129.

Kind of food.—White bread with milk.
Subject.—C. W. S.
Duration.—Two days, with six meals.

TABLE 10.—*Results of digestion experiment No. 129.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6007	White bread	2,042	1,240.4	193.9	16.5	1,030.0	15.5	5,509
6010	Milk	1,548	190.8	51.2	61.9	77.7	12.4	1,197
6011	do	2,064	262.5	68.3	87.7	106.5	15.7	1,666
	Total		1,693.7	313.4	166.1	1,214.2	43.6	8,372
	Feces (water-free)	76.9	60.2	25.3	9.6	25.3	16.7	342
	Estimated feces from food other than bread		7.6	2.4	1.5	3.7		42
	Estimated feces from bread		52.6	22.9	8.1	21.6		300
	Total amount digested		1,633.5	288.1	156.5	1,188.9	26.9	8,030
	Estimated digestible nutrients in bread		1,187.8	171.0	8.4	1,008.4		5,209
	Coefficients of digestibility of total food		*Per ct.* 96.5	*Per ct.* 91.9	*Per ct.* 94.2	*Per ct.* 97.9	*Per ct.* 61.7	*Per ct.* (95.9)
	Estimated coefficients of digestibility of bread alone		95.8	88.2	50.9	97.9		(94.6)
	Proportion of energy actually available to body:							
	In total food							91.6
	In bread alone							90.7

During this experiment the subject eliminated 2,505 grams urine, containing 1.68 per cent or 42.1 grams nitrogen. This makes the average nitrogen per day as follows: Income in food, 25.1 grams; outgo in urine, 21.1 grams, and in feces, 2 grams; making a gain of 2 grams nitrogen, corresponding to 12.5 grams protein.

DIGESTION EXPERIMENT No. 130.

Kind of food.—White bread with milk.

Subject.—P. F. F.

Duration.—Two days, with six meals.

TABLE 11.—*Results of digestion experiment No. 130.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6007	White bread	1,197.0	726.9	113.7	9.7	603.5	9.1	3,230
6010	Milk	1,826.6	225.3	60.5	73.1	91.7	14.6	1,428
6011	do	1,702.8	216.6	56.4	72.4	87.8	12.9	1,374
	Total		1,168.8	230.6	155.2	783.0	36.6	6,032
6027	Feces (water-free)	76.1	60.1	25.0	18.0	17.1	16.0	375
	Estimated feces from food other than bread		7.4	2.3	1.5	3.6		41
	Estimated feces from bread		52.7	22.7	16.5	13.5		334
	Total amount digested		1,108.7	205.6	137.2	765.9	20.6	5,657
	Estimated digestible nutrients in bread			91.0		590.0		2,896
	Coefficients of digestibility of total food		*Per ct.* 94.9	*Per ct.* 89.2	*Per ct.* 88.4	*Per ct.* 97.8	*Per ct.* 56.1	*Per ct.* (93.8)
	Estimated coefficients of digestibility of bread alone			80.1		97.8		(89.7)
	Proportion of energy actually available to body:							
	In total food							89.5
	In bread alone							86.1

During this experiment the subject eliminated 2,550 grams urine, containing 1.39 per cent or 35.4 grams nitrogen. This makes the average nitrogen balance as follows: Income in food, 18.5 grams; outgo in urine, 17.7 grams, and in feces, 2 grams; making a loss of 1.2 grams nitrogen, corresponding to 7.5 grams protein.

DIGESTION EXPERIMENT No. 131.

Kind of food.—Graham bread with milk.
Subject.—C. W. S.
Duration.—Two days, with six meals.

TABLE 12.—*Results of digestion experiment No. 131.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6034	Graham bread	1,593.0	1,096.3	161.0	20.5	914.8	48.0	4,830
6032	Milk	2,218.8	284.5	76.3	88.8	119.4	16.2	1,826
6033	.....do	2,579.0	340.1	85.4	101.8	152.9	19.1	2,112
	Total		1,720.9	322.7	211.1	1,187.1	83.3	8,768
6042	Feces (water-free)	153.3	126.6	39.4	11.9	75.3	26.7	637
	Estimated feces from food other than bread		10.6	3.2	1.9	5.5		58
	Estimated feces from bread		116.0	36.2	[illegible]	69.8		579
	Total amount digested		1,594.3	283.3	199.2	1,111.8	56.6	8,131
	Estimated digestible nutrients in bread		980.3	124.8	10.5	845.0		4,251
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food		92.6	87.8	94.4	93.7	68.0	(92.7)
	Estimated coefficients of digestibility of bread alone		89.4	77.5	51.3	92.4		(86.0)
	Proportion of energy actually available to body:							
	In total food							88.6
	In bread alone							84.8

During this experiment the subject eliminated 1,408 grams urine, containing 1.22 per cent or 17.2 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 25.8 grams; outgo in urine, 8.6 grams, and in feces, 3.2 grams; making a gain of 14 grams nitrogen, corresponding to 87.5 grams nitrogen.

DIGESTION EXPERIMENT No. 132.

Kind of food.—Graham bread with milk.
Subject.—F. H. M.
Duration.—Two days, with six meals.

TABLE 13.—*Results of digestion experiment No. 132.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6035	Graham bread	1,317.0	739.3	108.5	13.8	617.0	25.6	3,262
6032	Milk	1,341.6	172.0	46.1	53.7	72.2	9.8	1,104
6033	.....do	2,717.0	358.3	89.9	107.3	161.1	20.1	2,225
	Total		1,269.6	244.5	174.8	850.3	55.5	6,591
6043	Feces (water-free)	104.6	84.7	27.7	10.4	46.6	19.9	440
	Estimated feces from food other than bread		9.0	2.7	1.6	4.7		49
	Estimated feces from bread		75.7	25.0	8.8	41.9		391
	Total amount digested		1,184.9	216.8	164.4	803.7	35.6	6,151
	Estimated digestible nutrients in bread		663.6	83.5	5.0	575.1		2,871
	Coefficients of digestibility of total food		*Per ct.* 93.3	*Per ct.* 88.7	*Per ct.* 94.1	*Per ct.* 94.5	*Per ct.* 64.1	*Per ct.* (93.3)
	Estimated coefficients of digestibility of bread alone		89.8	77.0	36.3	93.2		(93.7)
	Proportion of energy actually available to body:							
	In total food							89.2
	In bread alone							84.8

During this experiment the subject eliminated 3,488 grams urine, containing 1.29 per cent or 45 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 19.6 grams; outgo in [illegible] 22.5 grams, and in feces, 2.2 grams; making a loss of 5.1 grams nitrogen, corresponding to 31.9 grams protein.

DIGESTION EXPERIMENT No. 133.

Kind of food.—Graham bread with milk.

Subject.—C. D. H.

Duration.—Two days, with six meals.

TABLE 14.—*Results of digestion experiment No. 133.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6030	Graham bread	1,361.0	629.7	92.0	12.3	525.4	26.2	2,788
6032	Milk	2,734.0	350.5	94.0	109.4	147.1	20.0	2,250
6033	.....do	2,889.6	381.1	95.6	114.1	171.4	21.4	2,367
	Total		1,361.3	281.6	235.8	843.9	67.6	7,405
6044	Feces (water-free)	97.5	77.6	22.8	7.8	47.0	19.9	391
	Estimated feces from food other than bread		12.4	3.8	2.2	6.4		68
	Estimated feces from bread		65.2	19.0	5.6	40.6		323
	Total amount digested		1,283.7	258.8	228.0	796.9	47.7	7,014
	Estimated digestible nutrients in bread		564.5	73.0	6.7	484.8		2,465
	Coefficients of digestibility of total food		*Per ct.* 94.3	*Per ct.* 91.9	*Per ct.* 96.7	*Per ct.* 94.4	*Per ct.* 70.6	*Per ct.* (94.7)
	Estimated coefficients of digestibility of bread alone		89.6	79.3	54.7	92.3		(88.4)
	Proportion of energy actually available to body:							
	In total food							90.4
	In bread alone							85.2

During this experiment the subject eliminated 2,433 grams urine, containing 0.87 per cent or 21.2 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 22.6 grams; outgo in urine, 10.6 grams, and in feces, 1.8 grams; making a gain of 10.2 grams nitrogen, corresponding to 63.8 grams protein.

DIGESTION EXPERIMENT No. 134.

Kind of food.—Graham bread with milk.
Subject.—P. F. F.
Duration.—Two days, with six meals.

TABLE 15.—*Results of digestion experiment No. 134.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6037	Graham bread	1,326.0	736.9	104.2	15.4	617.3	27.1	3,257
6032	Milk	2,165.2	277.6	74.5	86.6	116.5	15.8	1,782
6033	.....do	2,683.0	353.8	88.8	105.9	159.1	19.9	2,199
	Total		1,368.3	267.5	207.9	892.9	62.8	7,238
6045	Feces (water-free)	134.5	105.6	34.2	11.5	59.9	28.9	541
	Estimated feces from food other than bread		10.7	3.3	1.9	5.5		59
	Estimated feces from bread		94.9	30.9	9.6	54.4		482
	Total amount digested		1,262.7	233.3	196.4	833.0	33.9	6,697
	Estimated digestible nutrients in bread		642.0	73.3	5.8	562.9		2,775
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food		92.3	87.2	94.5	93.3	54.0	(92.5)
	Estimated coefficients of digestibility of bread alone		87.1	70.3	37.9	91.2		(85.2)
	Proportion of energy actually available to body:							
	In total food							88.5
	In bread alone							82.4

During this experiment the subject eliminated 2,745 grams urine, containing 1 per cent or 27.5 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 21.4 grams; outgo in urine, 13.8 grams, and in feces, 2.7 grams; making a gain of 4.9 grams nitrogen, corresponding to 30.6 grams protein.

DIGESTION EXPERIMENT No. 135.

Kind of food.—Entire wheat bread with milk.
Subject.—C. W. S.
Duration.—Two days, with six meals.

TABLE 16.—*Results of digestion experiment No. 135.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6047	Entire wheat bread	1,579.0	883.3	133.4	6.7	743.2	29.1	3,895
6046	Milk	2,064.0	266.0	71.0	85.6	109.4	14.9	1,692
6057	do	2,274.0	290.6	78.2	91.0	121.4	18.0	1,847
	Total		1,439.9	282.6	183.3	974.0	62.0	7,434
	Feces (water-free)	96.6	77.4	30.8	12.4	34.2	19.2	424
	Estimated feces from food other than bread		9.4	3.0	1.8	4.6		52
	Estimated feces from bread		68.0	27.8	10.6	29.6		372
	Total amount digested		1,362.5	251.8	170.9	939.8	42.8	7,010
	Estimated digestible nutrients in bread			105.6		713.6		3,523
	Coefficients of digestibility of total food		*Per ct.* 94.6	*Per ct.* 89.1	*Per ct.* 93.2	*Per ct.* 96.5	*Per ct.* 69.0	*Per ct.* (94.3)
	Estimated coefficients of digestibility of bread alone			79.2		96.0		(90.4)
	Proportion of energy actually available to body:							
	In total food							90.1
	In bread alone							87.1

During this experiment the subject eliminated 2,334 grams urine, containing 1.33 per cent or 31 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 22.6 grams; outgo in urine, 15.5 grams, and in feces, 2.5 grams; making a gain of 4.6 grams nitrogen, corresponding to 28.8 grams protein.

DIGESTION EXPERIMENT No. 136.

Kind of food.—Entire wheat bread with milk.

Subject.—P. F. F.

Duration.—Two days, with six meals.

TABLE 17.—*Results of digestion experiment No. 136.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6048	Entire wheat bread	1,949.0	1,130.0	171.0	8.2	950.8	37.3	4,989
6046	Milk	2,992.8	385.8	103.0	124.2	158.6	21.6	2,454
6057	do	2,585.0	330.3	88.9	103.4	138.0	20.4	2,100
	Total		1,846.1	362.9	235.8	1,247.4	79.3	9,543
	Feces (water-free)	75.8	55.8	23.3	6.5	26.0	20.0	295
6052	Estimated feces from food other than bread		12.0	3.8	2.3	5.9		67
	Estimated feces from bread		43.8	19.5	4.2	20.1		228
	Total amount digested		1,790.3	339.6	229.3	1,221.4	59.3	9,248
	Estimated digestible nutrients in bread		1,086.2	151.5	4.0	930.7		4,761
	Coefficients of digestibility of total food		*Per ct.* 97.0	*Per ct.* 93.6	*Per ct.* 97.2	*Per ct.* 97.9	*Per ct.* 74.8	*Per ct.* 96.9
	Estimated coefficients of digestibility of bread alone		96.1	88.6	48.4	97.9		95.5
	Proportion of energy actually available to body:							
	In total food							92.5
	In bread alone							91.6

During this experiment the subject eliminated 2,046 grams urine, containing 1.38 per cent or 28.2 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 29.1 grams; outgo in urine, 14.1 grams, and in feces, 1.9 grams; making a gain of 13.1 grams nitrogen, corresponding to 81.9 grams protein.

DIGESTION EXPERIMENT No. 137.

Kind of food.—Entire wheat bread with milk.
Subject.—A. B. O.
Duration.—Two days, with six meals.

TABLE 18.—*Results of digestion experiment No. 137.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6049	Entire wheat bread	1,600.0	923.8	139.0	6.9	777.9	30.2	4,093
6046	Milk	2,373.6	305.9	81.6	98.5	125.8	17.1	1,946
6057	do	2,585.0	330.3	88.9	103.4	138.0	20.4	2,100
	Total		1,560.0	309.5	208.8	1,041.7	67.7	8,139
6053	Feces (water-free)	78.6	60.0	22.5	8.1	29.4	18.6	320
	Estimated feces from food other than bread		10.7	3.4	2.0	5.3		59
	Estimated feces from bread		49.3	19.1	6.1	24.1		261
	Total amount digested		1,500.0	287.0	200.7	1,012.3	49.1	7,819
	Estimated digestible nutrients in bread		874.5	119.9	.8	753.8		3,832
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food		96.2	92.7	96.1	97.2	72.5	(96.1)
	Estimated coefficients of digestibility of bread alone		94.7	86.3	10.4	96.9		(93.6)
	Proportion of energy actually available to body:							
	In total food							91.7
	In bread alone							90.0

During this experiment the subject eliminated 3,450 grams urine, containing 1.14 per cent or 39.3 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 24.8 grams; outgo in urine, 19.7 grams, and in feces, 1.8 grams; making a gain of 3.3 grams nitrogen, corresponding to 20.6 grams protein.

DIGESTION EXPERIMENT No. 138.

Kind of food.—White bread with milk.
Subject.—A. J. P.
Weight (without clothing).—At beginning, 136.9 pounds; at end, 136.3 pounds.
Duration.—Two days, with six meals.

TABLE 19.—*Results of digestion experiment No. 138.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6064	White bread	1,328.6	806.1	120.5	25.9	659.7	17.1	4,744
6066	Milk	800.0	96.9	28.0	33.6	35.3	5.5	582
6068	do	1,800.0	224.8	66.4	75.6	82.8	12.6	1,438
6071	do	1,200.0	151.0	42.0	50.4	58.6	8.4	902
6067	Butter	185.0	159.7	2.4	157.3	.....	7.0	1,476
	Sugar	53.0	53.0	.....	.....	53.0	.....	211
	Total	.....	1,491.5	259.3	342.8	889.4	50.6	9,353
	Feces (water-free)	34.1	26.0	9.4	5.8	10.8	8.1	196
	Estimated feces from food other than bread	.....	10.6	2.8	3.2	4.6	.....	63
	Estimated feces from bread	.....	15.4	6.6	2.6	6.2	.....	133
	Total amount digested	.....	1,465.5	249.9	337.0	878.6	42.5	9,157
	Estimated digestible nutrients in bread	.....	790.7	113.9	23.3	653.5	.....	4,611
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food	.....	98.3	96.3	98.3	98.8	84.0	(97.9)
	Estimated coefficients of digestibility of bread alone	.....	98.1	94.5	89.9	99.1	.....	(97.2)
	Proportion of energy actually available to body:							
	In total food	.....	.....	.....	.....	.....	.....	94.6
	In bread alone	.....	.....	.....	.....	.....	.....	94.2

During this experiment the subject eliminated 2,749 grams urine, containing 1.42 per cent or 39 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 20.8 grams; outgo in urine, 19.5 grams, and in feces, 0.8 gram; making a gain of 0.5 gram nitrogen, corresponding to 3.1 grams protein.

DIGESTION EXPERIMENT No. 139.

Kind of food.—White bread with milk, butter, and sugar.

Subject.—B. R. M.

Weight (without clothing).—At beginning, 165.4 pounds; at end, 164.2 pounds.

Duration.—Two days, with six meals.

TABLE 20.—*Results of digestion experiment No. 139.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6065	White bread	1,642.2	1,006.4	150.9	30.7	824.8	21.2	4,664
6066	Milk	800.0	96.9	28.0	33.6	35.3	5.5	582
6068	do	1,455.0	181.7	53.7	61.1	66.9	10.2	1,163
6071	do	800.0	100.6	28.0	33.6	39.0	5.6	602
6067	Butter	259.6	224.0	3.4	220.6	.....	9.8	2,070
	Sugar	148.6	148.6	.....	.....	148.6	.....	592
	Total	.....	1,758.2	264.0	379.6	1,114.6	52.3	9,673

TABLE 20.—*Results of digestion experiment No. 139*—Continued.

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6070	Feces (water-free)	74.3	61.9	22.6	20.4	18.9	12.4	447
	Estimated feces from food other than bread		12.6	3.3	3.5	5.8		68
	Estimated feces from bread		49.3	19.3	16.9	13.1		379
	Total amount digested		1,696.3	241.4	359.2	1,095.7	39.9	9,226
	Estimated digestible nutrients in bread		957.1	131.6	13.8	811.7		4,285
	Coefficients of digestibility of total food		*Per ct.* 96.5	*Per ct.* 91.4	*Per ct.* 94.6	*Per ct.* 98.3	*Per ct.* 76.3	*Per ct.* (95.4)
	Estimated coefficients of digestibility of bread alone		95.1	87.2	45.0	98.4		(91.9)
	Proportion of energy actually available to body:							
	In total food							92.3
	In bread alone							88.3

During this experiment the subject eliminated 2,208 grams urine, containing 1.69 per cent or 37.3 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 21.1 grams; outgo in urine, 18.7 grams, and in feces, 1.8 grams; making a gain of 0.6 gram nitrogen, corresponding to 3.8 grams protein.

DIGESTION EXPERIMENT No. 140.

Kind of food.—White bread with milk, butter, and sugar.

Subject.—A. J. P.

Weight (without clothing).—At beginning, 134.5 pounds; at end, 134.5 pounds.

Duration.—Two days with six meals.

TABLE 21.—*Results of digestion experiment No. 140.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6077	White bread	1,168.6	716.3	104.9	27.9	583.5	15.8	3,325
6079	Milk	2,200.0	288.7	72.8	93.5	122.4	11.0	1,753
6080	....do	1,600.0	202.0	57.0	63.7	81.3	8.6	1,238
6081	Butter	146.4	122.7	2.0	120.7		6.9	1,133
	Sugar	59.6	59.6			59.6		238
	Total		1,389.3	236.7	305.8	846.8	42.3	7,687
6082	Feces (water-free)	44.0	32.5	10.9	5.7	15.9	11.5	247
	Estimated feces from food other than bread		10.8	2.7	2.8	5.3		62
	Estimated feces from bread		21.7	8.2	2.9	10.6		185
	Total amount digested		1,356.8	225.8	300.1	830.9	30.8	7,440
	Estimated digestible nutrients in bread		694.6	96.7	25.0	572.9		3,140
	Coefficients of digestibility of total food		*Per ct.* 97.7	*Per ct.* 95.4	*Per ct.* 98.1	*Per ct.* 98.1	*Per ct.* 72.8	*Per ct.* (96.8)
	Estimated coefficients of digestibility of bread alone		97.0	92.2	89.6	98.2		(93.2)
	Proportion of energy actually available to body:							
	In total food							93.1
	In bread alone							90.8

During this experiment the subject eliminated 2,322 grams urine, containing 1.54 per cent or 35.8 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 19 grams; outgo in urine, 17.9 grams, and in feces, 0.9 gram; making a gain of 0.2 gram nitrogen, corresponding to 1.3 grams protein.

DIGESTION EXPERIMENT No. 141.

Kind of food.—White bread with milk, butter, and sugar
Subject.—O. W. K.
Weight.—At beginning, 135.1 pounds; at end, 134 pounds.
Duration.—Two days with six meals.

TABLE 22.—*Results of digestion experiment No. 141.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6078	White bread	1,137.6	692.7	102.0	26.0	564.7	17.0	3,218
6079	Milk	2,200.0	288.7	72.8	93.5	122.4	11.0	1,753
6080	do	1,600.0	202.0	57.0	63.7	81.3	8.6	1,238
6081	Butter	135.6	113.7	1.9	111.8		6.4	1,040
	Sugar	80.4	80.4			80.4		321
	Total		1,377.5	233.7	295.0	848.8	43.0	7,570
6083	Feces (water-free)	42.0	32.4	10.8	5.0	16.6	9.6	242
	Estimated feces from food other than bread		11.1	2.7	2.7	5.7		64
	Estimated feces from bread		21.3	8.1	2.3	10.9		178
	Total amount digested		1,345.1	222.9	290.0	832.2	33.4	7,328
	Estimated digestible nutrients in bread		671.4	93.9	23.7	553.8		3,040
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total bread		97.7	95.4	98.3	98.1	80.0	(96.8)
	Estimated coefficients of digestibility of bread alone		96.9	92.1	91.2	98.1		(97.9)
	Proportion of energy actually available to body:							
	In total food							93.1
	In bread alone							90.8

During this experiment the subject eliminated 2,530 grams urine, containing 1.25 per cent or 31.6 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 18.7 grams; outgo in urine, 15.8 grams, and in feces, 0.9 gram; making a gain of 2 grams nitrogen, corresponding to 12.5 grams protein.

DIGESTION EXPERIMENT No. 142.

Kind of food.—Entire wheat bread with milk, butter, and sugar.
Subject.—A. J. P.
Weight (without clothing).—At beginning 132.5 pounds; at end 134.7 pounds.
Duration.—Two days with six meals.

TABLE 23.—*Results of digestion experiment No. 142.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6086	Entire wheat bread	1,247.6	751.7	117.6	32.7	601.4	17.5	3,567
6088	Milk	1,500.0	207.6	55.4	75.0	77.2	9.8	1,353
6089	....do	545.0	73.0	19.4	27.2	26.4	3.1	467
6090	Butter	248.8	201.5	2.0	199.5	.....	14.8	1,866
	Sugar	109.6	109.6	.....	.....	109.6	.....	437
	Total	.....	1,343.4	194.4	334.4	814.6	45.2	7,690
6091	Feces (water-free)	53.1	43.3	14.7	8.2	20.4	9.8	301
	Estimated feces from food other than bread	.....	8.8	1.5	3.0	4.3	.....	52
	Estimated feces from bread	.....	34.5	13.2	5.2	16.1	.....	249
	Total amount digested	.....	1,300.1	179.7	326.2	794.2	35.4	7,389
	Estimated digestible nutrients in bread	.....	717.2	104.4	27.5	585.3	.....	3,318
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food	.....	96.8	90.4	97.5	97.5	78.3	(96.1)
	Estimated coefficients of digestibility of bread alone	.....	95.4	88.8	84.0	97.3	.....	(96.9)
	Proportion of energy actually available to body:							
	In total food	.....	.....	.....	.....	.....	.....	93.2
	In bread alone	.....	.....	.....	.....	.....	.....	89.3

During this experiment the subject eliminated 2,042 grams urine, containing 1.40 per cent or 28.6 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 15.6 grams; outgo in urine, 14.3 grams, and in feces, 1.5 grams; making a gain of 0.1 gram nitrogen, corresponding to 0.6 gram protein.

DIGESTION EXPERIMENT No. 143.

Kind of food.—Entire wheat bread with milk, butter, and sugar.

Subject.—O. W. K.

Weight (without clothing).—At beginning, 135.5 pounds; at end, 135.1 pounds.

Duration.—Two days, with six meals.

TABLE 24.—*Results of digestion experiment No. 143.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6087	Entire wheat bread	1,210.4	723.9	112.5	32.5	578.9	16.6	3,424
6088	Milk	1,500.0	207.6	55.4	75.0	77.2	9.8	1,353
6089	....do	545.0	73.0	19.4	27.2	26.4	3.1	467
6090	Butter	267.6	216.8	2.2	214.6	.....	15.9	2,008
	Sugar	184.8	184.8	.....	.....	184.8	.....	737
	Total	.....	1,406.1	189.5	349.3	867.3	45.4	7,989

TABLE 24.—*Results of digestion experiment No. 143*—Continued.

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6092	Feces (water-free)	44.8	36.6	12.4	7.0	17.2	8.2	275
	Estimated feces from food other than bread		10.5	1.5	3.2	5.8		61
	Estimated feces from bread		26.1	10.9	3.8	11.4		214
	Total amount digested		1,369.5	177.1	342.3	850.1	37.2	7,714
	Estimated digestible nutrients in bread		697.8	101.6	28.7	567.5		3,210
	Coefficients of digestibility of total food		*Per ct.* 97.4	*Per ct.* 93.5	*Per ct.* 98.0	*Per ct.* 98.0	*Per ct.* 81.9	*Per ct.* (96.8)
	Estimated coefficients of digestibility of bread alone		96.4	90.4	88.2	98.0		(93.8)
	Proportion of energy actually available to body:							
	In total food							93.7
	In bread alone							90.0

During this experiment the subject eliminated 2,086 grams urine, containing 1.46 per cent or 30.5 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 15.2 grams; outgo in urine, 15.3, and in feces, 1 gram; making a loss of 1.1 grams nitrogen, corresponding to 6.9 grams protein.

DIGESTION EXPERIMENT No. 144.

Kind of food.—Graham bread with milk, butter, and sugar.

Subject.—A. J. P.

Weight (without clothing).—At beginning, 136.1 pounds; at end, 135.7 pounds.

Duration.—Two days, with six meals.

TABLE 25.—*Results of digestion experiment No. 144.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6097	Graham bread	1,584.1	892.4	113.3	47.1	732.0	25.0	4,180
6099	Milk	1,200.0	158.2	43.6	55.2	59.4	9.0	1,065
6100	.....do	1,000.0	125.0	33.8	46.0	45.2	6.2	814
6107	Butter	189.8	152.4	2.1	150.3		12.3	1,410
	Sugar	102.0	102.0			102.0		407
	Total		1,430.0	192.8	298.6	938.6	52.5	7,876
6103	Feces (water-free)	284.5	91.5	23.5	10.1	57.9	19.3	558
	Estimated feces from food other than bread		8.2	1.6	2.5	4.1		49
	Estimated feces from bread		83.3	21.9	7.6	53.8		509
	Total amount digested		1,338.5	169.3	288.5	880.7	33.2	7,318
	Estimated digestible nutrients in bread		809.1	91.4	39.5	678.2		3,671
	Coefficients of digestibility of total food		*Per ct.* 93.6	*Per ct.* 87.8	*Per ct.* 96.6	*Per ct.* 93.8	*Per ct.* 63.2	*Per ct.* (92.9)
	Estimated coefficients of digestibility of bread alone		90.7	80.7	83.9	92.7		(87.8)
	Proportion of energy actually available to body:							
	In total food							90.2
	In bread alone							85.1

During this experiment the subject eliminated 2,723 grams urine, containing 1.10 per cent or 30 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 15.4 grams; outgo in urine, 15 grams, and in feces, 1.9 grams; making a loss of 1.5 grams nitrogen, corresponding to 9.4 grams protein.

DIGESTION EXPERIMENT No. 145.

Kind of food.—Graham bread with milk, butter, and sugar.

Subject.—O. W. K.

Weight (without clothing).—At beginning, 136.2 pounds; at end, 136 pounds.

Duration.—Two days, with six meals.

TABLE 26.—*Results of digestion experiment No. 145.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6098	Graham bread	1,200.0	679.8	89.1	33.0	557.7	17.6	3,178
6099	Milk	1,400.0	184.5	50.8	64.4	69.3	10.5	1,243
6100	do	1,076.0	134.5	36.4	49.5	48.6	6.7	876
6107	Butter	201.4	161.7	2.3	159.4	.....	13.0	1,495
	Sugar	185.0	185.0	.....	.....	185.0	.....	738
	Total	.....	1,345.5	178.6	306.3	860.6	47.8	7,530
6104	Feces (water-free)	93.1	78.8	22.0	7.8	49.0	14.3	472
	Estimated feces from food other than bread	.....	10.6	1.8	2.7	6.1	.....	60
	Estimated feces from bread	.....	68.2	20.2	5.1	42.9	.....	412
	Total amount digested	.....	1,266.7	156.6	298.5	811.6	33.5	7,058
	Estimated digestible nutrients in bread	.....	611.6	68.9	27.9	514.8	.....	2,766
		–	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food	.....	94.1	87.7	97.5	94.3	70.1	(93.7)
	Estimated coefficients of digestibility of bread alone	.....	90.0	77.3	84.6	92.3	.....	(87.0)
	Proportion of energy actually available to body:							
	In total food	.....	.....	.....	.....	.....	.....	91.1
	In bread alone	.....	.....	.....	.....	.....	.....	84.3

During this experiment the subject eliminated 2,259 grams urine, containing 1.22 per cent or 27.6 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 14.3 grams; outgo in urine, 13.8 grams, and in feces, 1.8 grams; making a loss of 1.3 grams nitrogen, corresponding to 8.1 grams protein.

DIGESTION EXPERIMENT No. 146.

Kind of food.—White bread with milk, butter, and sugar. (Partial fasting.)

Subject.—O. W. K.

Weight (without clothing).—At beginning, 147.6 pounds; at end, 144.7 pounds.

Duration.—Two days, with six meals.

TABLE 27.—*Results of digestion experiment No. 146.*

Laboratory number.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
6120	White bread	568.0	344.8	51.3	7.6	285.9	6.5	1,595
6121	Milk	1,629.6	223.3	59.2	88.0	76.1	12.2	1,463
	Butter	67.8	56.0	.8	55.2	.....	2.8	516
	Sugar	40.2	40.2	.....	.....	40.2	.....	125
	Total	.....	664.3	111.3	150.8	402.2	21.5	3,699
6124	Feces (water-free)	12.4	9.3	2.4	1.5	5.4	3.1	50
	Estimated feces from food other than bread	.....	4.9	1.2	1.4	2.3	.....	29
	Estimated feces from bread	.....	4.4	1.2	.1	3.1	.....	21
	Total amount digested	.....	655.0	108.9	149.3	396.8	18.4	3,649
	Estimated digestible nutrients in bread	.....	340.4	50.1	7.5	282.8	.....	1,574
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Coefficients of digestibility of total food	.....	98.6	97.8	99.0	98.7	85.6	(98.6)
	Estimated coefficients of digestibility of bread alone	.....	98.7	97.7	99.1	98.9	.....	(98.7)
	Proportion of energy actually available to body:							
	In total food	.....	.....	.....	.....	.....	.....	95.0
	In bread alone	.....	.....	.....	.....	.....	.....	94.7

The quantity of food was limited in this experiment in order to obtain data for studying the amount of metabolic nitrogen in the feces, as explained on p. 39.

During this experiment the subject eliminated 1,529 grams urine, containing 1.58 per cent or 24.2 grams nitrogen. This makes the average nitrogen balance per day as follows: Income in food, 8.9 grams; outgo in urine, 12.1 grams, and in feces, 0.2 gram; making a loss of 3.4 grams nitrogen, corresponding to 21.3 grams protein.

In Table 28 are summarized the results obtained in the various digestion experiments for the digestibility of the total diet. In Table 29 these results are shown as computed for the digestibility of the different kinds of bread alone. It will be noticed that the digestibility of the bread in the first four experiments, in which no other food materials were consumed, was less than in the experiments in which milk was taken in addition.

TABLE 28.—*Summary of digestion experiments—Digestibility of nutrients and energy of total food.*

Number of experiment.	Kinds of food.	Subject.	Total organic matter.	Protein.	Fat.	Carbohydrates.	Ash.	Heat of combustion.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*
123	White bread	H. B. S.	96.8	90.9	82.3	98.3	43.9	92.7
124	do	H. B. S.	95.5	80.0	65.6	98.9	54.3	91.2
125	do	L. H. H.	94.6	81.7	67.5	97.7	32.6	90.3
126	do	I. W. F.	94.7	75.4	67.2	98.7	67.1	90.7
	White bread, average of 4.		95.4	82.0	70.7	98.4	49.5	91.2
127	White bread and milk	L. H. H.	95.2	86.5	89.6	98.0	78.8	94.1
128	do	H. B. S.	95.8	90.8	92.8	97.7	70.1	91.5
129	do	C. W. S.	96.5	91.9	94.2	97.9	61.7	91.6
130	do	P. F. F.	94.9	89.2	88.4	97.8	56.1	89.5
138	do	A. J. P.	98.3	96.3	98.3	98.8	84.0	94.6
139	do	B. R. M.	97.8	91.4	94.6	98.3	76.3	92.3
140	do	A. J. P.	97.7	95.4	98.1	98.1	72.8	93.1
141	do	O. W. K.	97.7	95.4	98.3	98.1	80.0	93.1
146	do	O. W. K.	98.6	97.8	99.0	98.7	85.6	95.0
	Average of Nos. 129, 130, 138, 140, 141. *a*		97.0	93.6	95.5	98.1	70.9	92.4
	Average of 9		96.9	92.8	94.8	98.2	73.9	92.8
131	Graham bread and milk	C. W. S.	92.6	87.8	94.4	93.7	68.0	88.6
132	do	F. H. M.	93.3	88.7	94.1	94.5	64.1	89.2
133	do	C. D. H.	94.3	91.9	96.7	94.4	70.6	90.4
134	do	P. F. F.	92.3	87.2	94.5	93.3	54.0	88.5
144	do	A. J. P.	93.6	87.8	96.6	93.8	63.2	90.2
145	do	O. W. K.	94.1	87.7	97.5	94.3	70.1	91.1
	Average of Nos. 131, 134, 144, 145 *a*.		93.1	88.6	95.8	93.8	63.8	89.6
	Average of 6		93.4	88.5	95.6	94.0	65.0	89.7
135	Entire wheat bread and milk	C. W. S.	94.6	89.1	93.2	96.5	69.0	90.1
136	do	P. F. F.	97.0	93.6	97.2	97.9	74.8	92.5
137	do	A. B. O.	96.2	92.7	96.1	97.2	72.5	91.7
142	do	A. J. P.	96.8	90.4	97.5	97.5	78.3	93.2
143	do	O. W. K.	97.4	93.5	98.0	98.0	81.9	93.7
	Average of Nos. 135, 136, 142, 143 *a*.		96.5	91.7	96.5	97.5	76.0	92.4
	Average of 5		96.4	91.9	96.4	97.4	75.3	92.2

a These averages are more strictly comparable than the average of all, as they include experiments upon the same subjects with all three kinds of flours.

Table 29 summarizes the calculated digestibility of the bread alone in the preceding experiments.

TABLE 29.—*Digestibility of nutrients and energy of bread alone.*

Number of experiment.	Kinds of food.	Subject.	Total organic matter.	Protein.	Fat.	Carbohydrates.	Heat of combustion.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*
123	White bread	H. B. S.	96.8	90.9	82.3	98.3	92.7
124	do	H. B. S.	95.5	80.0	65.6	98.9	91.2
125	do	L. H. H.	94.6	81.7	67.5	97.7	90.3
126	do	L. W. F.	94.7	75.4	67.2	98.7	90.7
127	do	L. H. H.	94.3	79.6	70.8	98.0	94.3
128	do	H. B. S.	94.5	83.2	63.1	97.6	89.9
129	do	C. W. S.	95.8	88.2	50.9	97.9	90.7
130	do	P. F. F.	.....	80.1	.....	97.8	86.1
138	do	A. J. P.	98.1	94.5	89.9	99.1	94.2
139	do	B. R. M.	95.1	87.2	45.0	98.4	88.3
140	do	A. J. P.	97.0	92.2	89.6	98.2	90 8
141	do	O. W. K.	96.9	92.1	91.2	98.1	90.8
146	do	O. W. K.	98.7	97.7	99.1	98.9	94.7
	Average of Nos. 129, 130, 138, 140, 141.		*a* 97.0	89.4	*b* 80.4	98.2	90.5
	Average of all (13)		96.0	86.4	73.5	98.3	91.1

a Not including No. 130.

TABLE 29.—*Digestibility of nutrients and energy of bread alone*—Continued.

Number of experiment.	Kinds of food.	Subject.	Total organic matter.	Protein.	Fat.	Carbohydrates.	Heat of combustion.
			Per ct.	*Per ct.*	*Per ct.*	*Per cent.*	*Per cent.*
131	Graham bread	C. W. S.	89.9	77.5	51.3	92.4	84.8
132	do	F. H. M.	89.8	77.0	36.3	93.2	84.8
133	do	C. D. H.	89.6	79.3	54.7	92.3	85.2
134	do	P. F. F.	87.1	70.3	37.9	91.2	82.4
144	do	A. J. P.	90.7	80.7	83.9	92.7	85.1
145	do	O. W. K.	98.9	77.3	84.6	92.5	84.3
	Average of Nos. 131, 134, 144, 145.		91.7	76.5	64.4	92.2	84.2
	Average of all (6)		91.0	77.0	58.1	92.4	84.4
135	Entire wheat bread	C. W. S.	.....	79.2	.....	96.0	87.1
136	do	P. F. F.	96.1	88.6	48.4	97.9	91.6
137	do	A. B. O.	94.7	86.3	10.4	96.9	90.0
142	do	A. J. P.	95.4	88.8	84.0	97.3	89.3
143	do	O. W. K.	96.4	90.4	88.2	98.0	90.0
	Average of Nos. 135, 136, 142, 143.		a 96.0	86.8	a 73.5	97.3	89.5
	Average of all (5)		95.7	86.7	57.8	97.2	89.6

a Not including No. 135.

As previously stated (p. 15), it is a matter of common observation that digestion experiments made with one kind of food material do not give on the whole as reliable results as those in which two or more food materials are used. In other words, it appears that with a mixed diet the same person will digest a larger proportion of nutrients than with a diet composed of a single food material. Thus, as shown in a recent compilation, the average of 10 experiments with an exclusively milk diet[1] gave 92.1 per cent as the amount of protein and 86.3 per cent as the amount of carbohydrates which was digestible. Five experiments made with an exclusively bread diet or with bread and sugar showed 82 per cent of the protein and 99 per cent of the carbohydrates to be digested. Five experiments with a diet of bread and milk showed 97 per cent of the protein and 98.7 per cent of the carbohydrates to be digested. In other words, the protein in milk alone or in bread alone seems to be much less completely digested than when the two are eaten together. For this reason in the majority of digestion experiments milk was consumed ad libitum with bread. Small amounts of butter and sugar were also eaten. The greater coefficient of digestibility of bread and milk as compared with that of bread alone is shown by the comparison of the results of experiments Nos. 123–126 with those of experiments Nos. 127–130.

METABOLIC PRODUCTS IN FECES.

It has already been said that the feces are not made up entirely of undigested residue of food, but contain quite large amounts of other waste materials. These materials, the "Stoffwechselproducte" of German investigators, are usually designated by English writers as meta-

[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 21, p. 61, and Connecticut Storrs Sta. Rpt. 1896, p. 163.

bolic products. This term as ordinarily used includes, however, not only the metabolic products, strictly speaking, such as the residues from the bile, mucus, saliva, gastric juices, pancreatic juices, and other digestive secretions, but also includes worn-out particles from the mucus membrane lining the intestines, and other débris from the walls of the stomach, etc. The results of the recent investigations indicate that the digestion of food materials is more complete and the proportion of metabolic products in the feces is larger than was formerly supposed. It is not at all improbable that during the processes of natural digestion, aided by careful preparation of the food and proper mastication, practically all of the nutrients of most foods are rendered absorbable in the alimentary canal and that undigested residues are rather accidental than incidental. Much study is now being given to this subject and attempts are being made by chemical and microscopical methods to determine the amounts of metabolic products excreted daily in the feces. In view of the importance of this kind of work, the metabolic nitrogen of the feces was studied in the experiments above reported and in two supplementary experiments in which the subject consumed no nitrogenous food. These results are reported without any extended discussion as a contribution to the knowledge of the question of the amount of metabolic nitrogen in the feces. Such experiments are being continued, and when more data have been accumulated and a review of the literature of this subject can be prepared, a general discussion of this question may be in order.

In the experiments at the Maine Station various chemical and physical methods have been adopted for determining the metabolic products in the feces. The quantity of such material may be approximately learned (1) by treating the feces with certain solvents; (2) by determining the amount of nitrogen in the feces during a carbohydrate diet; and (3) by determining the amount and composition of feces during complete or partial fasting.

TREATMENT OF FECES WITH PEPSIN SOLUTION.

Grouven as early as 1867 observed in experiments with animals that the feces sometimes contain more nitrogen than the food ingested. Schulze and Maercker[1] attempted to determine the amount of metabolic nitrogen by separating it from the feces with boiling alcohol and boiling ether. For several years this method was employed, but was shown by different investigators to be unreliable. In 1885 Stutzer[2] proposed to dissolve out the metabolic nitrogenous matter by digesting it with freshly prepared pepsin solution. This method was modified and improved upon by Pfeiffer,[3] and in general has been followed in this

[1] Jour. Landw., 19 (1871), p. 46.

[2] Ztschr. Physiol. Chem., 10 (1886), p. 153.

[3] Ztschr. Physiol. Chem., 10 (1886), pp. 170 and 561, and Jour. Landw., 34 (1886), p. 425.

country at the Maine, New York, Maryland, and other agricultural experiment stations where such work has been carried on. The method is described in earlier publications of the Maine Station.[1] In the same publications a modified method for determining metabolic nitrogen by treating the feces with ether, alcohol, water, and lime-water is described.

A portion of the feces in digestion experiments Nos. 127–146, inclusive, described above, was treated with pepsin solution according to the usual method. This solution was prepared by dissolving 1.25 grams German plain soluble pepsin in 1 liter of 0.2 per cent hydrochloric acid, made by adding 20 cubic centimeters of a solution containing exactly 10 per cent hydrochloric acid gas to 1 liter of water, and adding 5 cubic centimeters of a solution of thymol in alcohol as a preservative. A weighed sample of finely ground feces was placed in a beaker with 200 cubic centimeters of this solution, which had previously been heated to 50° C. The whole was placed in a water bath at 40° C. for eight hours on two successive days. At intervals of two hours 1 cubic centimeter of 10 per cent hydrochloric acid was added until the final strength of the solution was 0.5 per cent. On the day following the second digestion the solution was decanted upon folded filters. The residue was washed by decantation and also upon the filter until no proteids were obtained on testing the wash water. The filter and contents were dried. As much as possible of the top of the filter was cut off. The nitrogen in the dried material, which was assumed to represent the nitrogen of undigested material, was determined by the Kjeldahl method, a suitable correction being made in the results for the small amount of nitrogen of the filter paper. The results obtained by this method, as applied to the feces in experiments Nos. 123–127, are shown in Table 30.

TREATMENT OF FECES WITH ETHER, ALCOHOL, HOT WATER, AND COLD LIMEWATER.

As has already been stated, the method of determining the amount of metabolic nitrogen in feces by treatment with ether, alcohol, hot water, and cold limewater has been in use at the Maine Station for some years. The method of manipulation is as follows:

One gram of finely ground feces is boiled for one-half hour with 25 cubic centimeters water-free ether in a small flask with a reversed condenser, the ether decanted upon a filter, and the operation repeated. After washing with ether by decantation, 50 cubic centimeters of 95 per cent alcohol is poured upon the residue of the feces in the flask and boiled for 10 minutes, a reversed condenser being used, as before. The alcohol is decanted upon the same filter as was used for the ether extract and the whole washed with hot alcohol. The sample of feces is then

[1] Maine Sta. Rpts. 1887, p. 128; 1888, p. 210; and 1889, p. 282.

heated on a steam bath for 20 minutes with 50 cubic centimeters of water and the whole washed with hot water upon the same filter as before. Feces and filter are then placed in a beaker with 50 cubic centimeters of limewater (a saturated solution), and allowed to stand for 6 hours. The whole is then thoroughly washed upon a fresh filter with dilute limewater and, after drying, the nitrogen determined in the residue by the Kjeldahl method, a correction being applied for the nitrogen in the filters. The results of this method of making correction for the metabolic nitrogen of feces in the digestion experiments Nos. 123–146 are also shown in Table 30.

The table showing the correction obtained by the two methods includes the total weight of partially dried feces, the percentage nitrogen in this material and in the residue of feces not dissolved by treatment with pepsin or with ether, alcohol, and limewater. Various results computed with the aid of these figures and those given in Tables 4–27 are also shown.

TABLE 30.—*Digestible nitrogen corrected for metabolic nitrogen of feces determined by treatment with pepsin solution and by extraction with ether, alcohol, hot water, and limewater.*

	Nitrogen in food.	Weight of feces.[a]	Nitrogen in feces.		Treatment with pepsin.				Treatment with ether, alcohol, hot water, and limewater.			
					Nitrogen of feces undissolved by treatment.		Nitrogen digested.		Nitrogen of feces undissolved by treatment.		Nitrogen digested.	
	Gms.	*Gms.*	*P. ct.*	*Gms.*	*P. ct.*	*Gms.*	*Gms.*	*P. ct.*	*P. ct.*	*Gms.*	*Gms.*	*P. ct.*
Digestion experiment No. 123, with white bread: Entire diet (=bread alone)	22.94	41.0	5.10	2.10	2.11	0.87	22.07	96.21	3.88	1.60	21.34	92.60
Digestion experiment No. 124, with white bread: Entire diet (=bread alone)	13.28	34.0	7.83	2.66	2.30	.78	12.50	94.19	3.76	1.28	12.00	90.37
Digestion experiment No. 125, with white bread: Entire diet (=bread alone)	15.01	50.0	6.66	3.33	2.79	1.39	13.62	90.74	4.29	2.14	12.87	85.74
Digestion experiment No. 126, with white bread: Entire diet (=bread alone)	14.93	46.0	8.00	3.68	2.32	1.07	13.86	92.90	3.88	1.78	13.15	88.07
Digestion experiment No. 127, with white bread and milk:												
Entire diet	24.24	56.0	5.86	3.28	2.71	1.52	22.72	93.73	4.46	2.50	21.74	89.70
Bread alone	15.20	.....	.....	3.10	.....	1.44	13.76	90.55	.....	2.36	12.84	84.49
Digestion experiment No. 128, with white bread and milk:												
Entire diet	27.60	56.0	4.53	2.54	1.52	.85	26.75	96.92	3.27	1.83	25.77	93.37
Bread alone	13.42	.....	.....	2.26	.....	.76	12.66	94.37	.....	1.63	11.79	87.89
Digestion experiment No. 129, with white bread and milk:												
Entire diet	50.14	84.0	4.82	4.05	1.70	1.43	48.71	97.15	3.06	2.57	47.57	94.89
Bread alone	31.02	.....	.....	3.66	.....	1.30	29.72	95.80	.....	2.33	28.69	92.50
Digestion experiment No. 130, with white bread and milk:												
Entire diet	36.90	82.0	4.89	4.01	1.59	1.30	35.60	96.47	3.45	2.83	34.07	92.35
Bread alone	18.19	.....	.....	3.63	.....	1.18	17.01	97.08	.....	2.57	15.62	85.88
Digestion experiment No. 131, with Graham bread and milk:												
Entire diet	51.64	168.0	3.75	6.30	1.52	2.55	47.09	95.09	2.97	4.99	46.65	90.37
Bread alone	25.76	.....	.....	5.79	.....	2.34	23.42	90.93	.....	4.58	21.18	82.22

[a] This represents the weight of the feces "partially dry." For explanation of method of partial drying, see U. S. Dept. Agr., Office of Experiment Stations Bul. 44, p. 24.

TABLE 30.—*Digestible nitrogen corrected for metabolic nitrogen of feces determined by treatment with pepsin solution and by extraction with ether, alcohol, hot water, and lime-water*—Continued.

	Nitrogen in food.	Weight of feces.	Nitrogen in feces.		Treatment with pepsin.				Treatment with ether, alcohol, hot water, and limewater.			
					Nitrogen of feces undissolved by treatment.		Nitrogen digested.		Nitrogen of feces undissolved by treatment.		Nitrogen digested.	
Digestion experiment No. 132, with Graham bread and milk:	*Gms.*	*Gms.*	*P. ct.*	*Gms.*	*P. ct.*	*Gms.*	*Gms.*	*P. ct.*	*P. ct.*	*Gms.*	*Gms.*	*P. ct.*
Entire diet	39.12	115.0	3.86	4.44	1.65	1.90	37.22	95.13	2.75	3.16	35.96	91.93
Bread alone	17.36	.....	.....	4.00	.....	1.72	15.64	90.10	.....	2.85	14.51	83.60
Digestion experiment No. 133, with Graham bread and milk:												
Entire diet	45.05	108.0	3.38	3.65	1.03	1.11	43.94	97.55	2.48	2.68	42.37	94.05
Bread alone	15.36	.....	.....	3.04	.....	.93	14.43	93.95	.....	2.23	13.13	85.48
Digestion experiment No. 134, with Graham bread and milk:												
Entire diet	42.80	150.0	3.65	5.48	1.20	1.80	41.00	95.80	2.52	3.78	39.02	91.19
Bread alone	16.69	.....	.....	4.94	.....	1.63	15.06	90.23	.....	3.42	13.27	79.50
Digestion experiment No. 135, with entire wheat bread and milk:												
Entire diet	45.21	104.0	4.74	4.93	1.83	1.90	43.31	95.80	3.50	3.64	41.57	91.97
Bread alone	21.34	.....	.....	4.45	.....	1.72	19.62	96.35	.....	3.29	18.05	84.58
Digestion experiment No. 136, with entire wheat bread and milk:												
Entire diet	58.07	82.0	4.55	3.73	1.34	1.10	56.97	98.10	3.47	2.84	55.23	95.10
Bread alone	27.36	.....	.....	3.12	.....	.92	26.44	96.65	.....	2.38	24.98	91.30
Digestion experiment No. 137, with entire wheat bread and milk:												
Entire diet	49.52	88.0	4.10	3.61	1.20	1.06	48.46	97.85	2.73	2.40	47.12	95.15
Bread alone	22.24	.....	.....	3.06	.....	.90	21.34	95.95	.....	2.04	20.20	90.83
Digestion experiment No. 138, with white bread and milk:												
Entire diet	41.49	36.0	4.17	1.50	1.16	.42	41.07	99.00	2.75	.99	40.50	97.65
Bread alone	19.28	.....	.....	1.06	.....	.30	18.98	98.47	.....	.70	18.58	96.39
Digestion experiment No. 139, with white bread and milk:												
Entire diet	42.24	82.4	4.39	3.62	.92	.76	41.48	98.20	1.78	1.47	40.77	95.55
Bread alone	21.14	.....	.....	3.09	.....	.65	22.49	98.17	.....	1.26	22.88	94.79
Digestion experiment No. 140, with white bread and milk:												
Entire diet	37.87	45.8	3.79	1.74	1.09	.50	37.87	98.67	2.55	1.17	36.70	96.93
Bread alone	16.42	.....	.....	1.31	.....	.37	16.42	97.80	.....	.88	15.91	94.77
Digestion experiment No. 141, with white bread and milk:												
Entire diet	37.39	43.8	3.94	1.73	1.27	.56	36.83	98.50	2.73	1.20	36.19	96.80
Bread alone	16.32	.....	.....	1.30	.....	.47	15.90	97.43	.....	.89	15.43	94.55
Digestion experiment No. 142, with entire wheat bread and milk:												
Entire diet	31.10	60.0	3.92	2.35	1.45	.87	30.23	97.19	2.77	1.66	29.44	94.65
Bread alone	18.82	.....	.....	2.11	.....	.78	18.04	95.86	.....	1.48	17.34	92.10
Digestion experiment No. 143, with entire wheat bread and milk:												
Entire diet	30.33	50.6	4.36	2.21	1.45	.74	29.59	97.57	2.78	1.41	28.92	95.39
Bread alone	18.00	.....	.....	1.74	.....	.66	17.34	96.33	.....	1.25	16.75	93.05
Digestion experiment No. 144, with Graham bread and milk:												
Entire diet	30.84	115.4	3.26	3.76	1.31	1.51	29.33	95.09	2.24	2.58	28.26	91.57
Bread alone	18.13	.....	.....	3.50	.....	1.41	16.72	92.22	.....	2.41	15.72	86.92
Digestion experiment No. 145, with Graham bread and milk:												
Entire diet	28.55	96.8	3.64	3.52	1.27	1.23	27.32	95.72	2.61	2.52	26.03	91.19
Bread alone	14.26	.....	.....	3.23	.....	1.13	13.13	92.07	.....	2.31	11.95	83.82
Digestion experiment No. 146, with white bread and milk:												
Entire diet	17.81	13.0	2.87	.37	1.47	.19	17.62	98.99	.....	.32	17.49	98.20
Bread alone	8.21	.....	.....	.19	.....	.09	8.12	98.90	.....	.16	8.05	98.05

The explanation of these tables is, perhaps, best illustrated by discussing experiment No. 127 in detail, which is chosen because it is the first in which some other food was taken in addition to bread. During the two days of this experiment the total feces partially dried weighed 56 grams. This contained 5.86 per cent nitrogen, making a total of 3.28 grams of nitrogen thus eliminated. By treatment with pepsin 3.15 per cent of the nitrogen of the feces was dissolved, leaving 2.71 per cent nitrogen undissolved. By treating the feces with ether, alcohol, hot water, and limewater according to the second method mentioned, 4.46 per cent nitrogen was left undissolved. The total nitrogen not dissolved by treatment with pepsin amounted to ($56 \times 2.71 =$) 1.52 grams, and that not dissolved by treatment with ether, alcohol, hot water, and limewater amounted to ($56 \times 4.46 =$) 2.50 grams. The quantity of nitrogen in the feces from bread alone was estimated as 16 per cent of the protein of the feces from bread ($19.4 \times 16 = 3.10$). The nitrogen not dissolved by treatment, in the feces from bread alone, described above, is obtained by assuming that the ratio of metabolic nitrogen to total nitrogen in the feces from bread would be the same as the ratio of metabolic nitrogen to the total nitrogen in the feces from the entire diet. In other words, it was assumed that the total nitrogen in the feces bears the same relation to the total nitrogen in the feces from bread alone that the total nitrogen not dissolved by treatment bears to the nitrogen not dissolved in the feces from bread alone. Thus, in experiment No. 127 (see p. 17), the nitrogen in the feces from bread not dissolved by treatment with pepsin is 1.44, computed according to the following proportion: 3.28 : 1.52 : : 3.10 : 1.44. In the same way the nitrogen in the feces from bread not dissolved by treatment with ether, alcohol, hot water, and limewater is 2.36, obtained according to the proportion 3.28 : 2.50 : : 3.10 : 2.36. According to the above assumption the proportion of metabolic products from the digestion of milk and other foods besides bread would be the same as from the digestion of bread itself. While we have no definite warrant for this assumption, the results can be but slightly affected by considerable variations in the relative amounts, owing to the small quantity of nitrogen in the feces from these other foods. The nitrogen in the total food eaten and in the bread is obtained by taking 16 per cent of the corresponding values for protein, as shown in the details of this experiment given in Table 8 on page 17. The amounts actually digested are obtained by subtracting the nitrogen not dissolved by treatment with pepsin or by treatment with ether, alcohol, hot water, and limewater from the total nitrogen in the food eaten, while the percentages actually digested are computed in the usual way by dividing the amounts actually digested by the amounts in the total food. It is of course evident that the coefficients of digestibility of protein would be the same as those for nitrogen.

METABOLIC NITROGEN IN THE FECES ON A CARBOHYDRATE DIET AND DURING FASTING.

During the past fifteen years a number of investigators have studied the amount and composition of the feces when a diet limited to carbohydrates was consumed, and during periods of partial or complete fasting, since it was believed that if no nitrogen was consumed, that obtained in the feces must be nitrogen of metabolic products. Very many of the experiments of this nature have been made with lower animals, especially dogs. While many important observations and deductions have been obtained by these studies, the results after all have thrown but little light on the amount of metabolic nitrogen normally present in the feces. Voit found, in experiments with a dog having a biliary fistula, that three times as much bile was discharged when a meat diet was consumed as when fasting. It was observed further that the amount of feces from a meat diet was not proportional to the quantity of meat eaten, as must be the case if the feces were composed solely of undigested food. As a matter of fact the weight of the feces when 600 grams of meat was eaten daily was only 2 grams greater than the quantity obtained when the dog fasted.

Carbohydrate diet.—In order to determine the amount of nitrogen in the feces when little or no nitrogen was ingested in the food, an experiment of two days' duration was carried on with a healthy man—the subject of Experiment No. 123, previously reported (p. 13)—in which the food consisted of tapioca. This was allowed to soak in water over night, was then cooked to a paste, and eaten with sugar, salt, and a little flavoring matter. The air-dry tapioca contained 11.97 per cent water. The percentage composition of the water-free tapioca was as follows: Protein 0.79, carbohydrates 98.90, and ash 0.31. The sugar was assumed to be pure, and therefore nitrogen-free.

The same amount of carbohydrates was taken as in digestion experiment No. 123 with wheat bread, namely, 861.1 grams (see Table 4). The fresh feces during the two days weighed 131.4 grams. The partially dried feces weighed 19 grams, and contained 6.5 per cent of nitrogen. The assumption seems warranted that this was all nitrogen of metabolic products. Theoretically all the nitrogenous metabolic products in the feces should be soluble in a pepsin solution. As a matter of fact only 69.4 per cent of the nitrogen in the feces from this nitrogen-free diet was rendered soluble by a pepsin solution, while ether, alcohol, hot water, and limewater extracted only 43.7 per cent of it. The results of these experiments are given in Table 33.

Fasting.—The composition of the feces during fasting is not well known. Five experiments with man along these lines have been

reported and have been summarized together with the results of other metabolism experiments in a recent bulletin of this Office.[1]

For the purpose of obtaining information upon the question of the amount and composition of the feces during fasting, an experiment of two days' duration was made, during which time no food whatever was eaten. The feces were marked at the beginning and end of the experimental period with milk and charcoal, as usual. The feces excreted each day were kept separate, as was also the urine. There was almost no difference in the amount and composition of the feces on the two days. During the first day 534.1 grams of urine was excreted, containing 2.04 per cent of nitrogen, and on the second day 522.3 grams, containing 2.49 per cent of nitrogen, or about 2 grams more than on the first day.

Table 33 summarizes the results of this experiment and that in which the diet consisted of carbohydrates, and includes for purposes of comparison the results obtained in experiments Nos. 123 and 124 with the same subject, when bread only was eaten.

Experiment No. 146, reported on page 30, was carried on with an insufficient amount of food, and is called a "partial fasting experiment." This and No. 141 with the same subject on a full diet of the same articles are also included for purposes of comparison. The subject of these experiments was not the same as in the other experiments shown in the table, and perhaps the results are, therefore, not strictly comparable.

No explanation of the figures in the table is required, unless it be of those in the last column headed "Protein oxidized." These were computed from the nitrogen in the urine on the supposition that this nitrogen is a measure of the amount of protein broken down in the body, and that this protein contained 16 per cent nitrogen.

TABLE 31.—*Comparison of protein metabolized and nitrogen excreted in the feces, with different diets and during fasting.*

Kind of experiment.	Subject.	Total weight.	Amount carbohydrates.	Nitrogen.		Protein oxidized.
Bread diet (No. 123).	H. B. S.	*Grams.*	*Grams.*	*Per cent.*	*Grams.*	*Grams.*
Income: Bread		816.5	430.5	1.40	11.43	
Outgo:						
Feces (partially dried)		20.3		5.18	1.06	
Urine		1,071.0		1.81	19.38	121.1
Total					20.44	
Bread diet (No. 124).	H. B. S.					
Income: Bread		478.0	260.2	1.39	6.64	

[1] See summary of these experiments and those in which the diet consisted of nitrogen-free materials in U. S. Dept. of Agr., Office of Experiment Stations Bul. 45, pp. 88, 68, and 78.

TABLE 21.—*Comparison of protein metabolized and nitrogen excreted in the feces, with different diets and during fasting*—Continued.

Kind of experiment.	Subject.	Total weight.	Amount carbohydrates.	Nitrogen.		Protein oxidized.
Bread diet (No. 124)—Continued.	H. B. S.					
Outgo:		*Grams.*	*Grams.*	*Per cent.*	*Grams.*	*Grams.*
Feces (partially dried)		17.0		7.83	1.33	
Urine		775.0		1.20	9.28	58.0
Total					10.61	
Carbohydrate diet.	H. B. S.					
Income:						
Tapioca		194.4	174.1	.79	1.40	
Sugar		256.4	256.4			
Total			430.5		1.40	
Outgo:						
Feces (partially dried)		9.5		6.50	.62	
Urine		1,597.6		.48	7.67	47.9
Total					8.29	
Fasting.	H. B. S.					
Outgo:						
Feces		8.0		5.44	.44	
Urine		528.2		2.27	11.96	74.8
Total					12.40	
Mixed diet (No. 146). Partial fasting.	O. W. K.					
Income:						
Bread		284.0		1.45	4.12	
Milk		814.8		.58	4.73	
Butter		33.9		.20	.68	
Sugar		20.1				
Total			201.1		9.53	
Outgo:						
Feces (partially dried)		6.5		2.87	.19	
Urine		765.0		1.58	12.08	75.5
Total					12.27	
Mixed diet (No. 141).	O. W. K.					
Income:						
Bread		568.8		1.43	8.13	
Milk		1,100.0		.53	5.83	
Do		800.0		.57	4.56	
Butter		67.8		.22	.15	
Sugar		40.2				
Total			424.4		18.67	
Outgo:						
Feces (partially dried)		21.9		3.94	.86	
Urine		1,265.0		1.25	15.81	98.8
Total					16.67	

The power of carbohydrates to protect protein from cleavage in the body becomes apparent when the amount of protein metabolized on the carbohydrate diet, as shown by the last column in the table, is compared with the corresponding amount during the period of fasting. During this latter period 50 per cent more body protein was oxidized than was the case during the period in which carbohydrates were eaten. The minimum cleavage of protein in the body in these tests was not reached during fasting, as Voit claims may be done, since with a carbohydrate diet a much smaller cleavage of protein was found. This is in

accord with the results obtained by Munk. As regards the metabolized nitrogen of metabolic products in the feces, it will be seen that there was more nitrogen in the feces during the period on a carbohydrate diet than during either period on the bread diets. This would seem to indicate that a very large part of the nitrogen in the feces from an ordinary diet is due to metabolic products required for the digestion of the various nutrients of the food. Even in fasting, when no digestive juices were required by the presence of food in the intestinal tract, a considerable amount of nitrogen was eliminated in the urine, amounting to one-third the amount found when a bread diet was eaten. The data obtained are regarded as insufficient for other and more general deductions, and as the authors are continuing their experiments, no further discussion will be attempted at present.

ARTIFICIAL DIGESTION OF BREAD WITH PEPSIN.

In 1880 Stutzer[1] published the results of an investigation upon the solubility of proteids in pepsin solution, from which he concluded that he had found a method for determining the digestible proteids of food with great exactness. Pfeiffer,[2] Kühn,[3] Wolff,[4] and especially Stutzer,[5] during the next ten years made exhaustive and comparative studies of the conditions and methods best adapted for the artificial digestion of proteids. The method thus elaborated and brought into general use is described by Wiley,[6] and is practically the method used in the following experiments. After tests with various sorts, the German plain pepsin was selected for the experiments. It is fully as active as any, gives a clear solution, and is free from proteids. The pepsin solution was prepared by dissolving 1.25 grams pepsin in 1 liter of 0.2 per cent of hydrochloric acid. In earlier work at the station a stronger solution was used, but repeated tests showed that for 1 gram of bread a solution containing 1.25 grams pepsin to the liter proved as efficient as the stronger solution, or, indeed, as one containing four times that amount. The manipulation was practically the same as that noted above in describing the treatment of feces with pepsin solution to learn the amount of true undigested protein present. The bread was prepared for analysis by drying and grinding in the usual way; that is, the material was in the condition known as "partially dry." Two hundred cubic centimeters of the pepsin solution was added to 1 gram of bread in a suitable beaker,

[1] Jour. Landw., 28 (1880), pp. 195, 435.

[2] Ztschr. Physiol. Chem., 10 (1886), p. 561; 11 (1887), p. 1.

[3] Landw. Vers. Stat., 44 (1894), p. 188.

[4] Landw. Jahrb., 19 (1890), p. 842.

[5] Ztschr. Physiol. Chem., 9 (1885), p. 211; 10 (1886), p. 156; 11 (1887), p. 361; Jour. Landw., 29 (1881), p. 478.

[6] Principles and Practice of Agricultural Analysis, vol. 3, p. 555.

stirred thoroughly, and placed in a water bath heated to 50° or 60° C. The digestion was begun at 8 o'clock in the morning, and was continued for eight hours on two consecutive days, fresh hydrochloric acid being added every two hours. The beaker was then allowed to stand over night, and on the following morning the supernatent liquid was decanted upon folded filters, the residue washed by decantation, transferred to the filter, and again the whole washed until no proteids could be obtained on testing the filtrate. The filter and contents were then dried and the nitrogen determined by the usual method, a suitable correction being made for the nitrogen of the filter paper.

Using this method, tests were made of the digestibility of 12 samples of white bread, 5 samples of whole wheat bread, and 6 samples of Graham bread. The results obtained are shown in Table 32.

TABLE 32.—*Digestibility of breads of different sorts by pepsin solution.*

Laboratory number.	Kind of bread.	Nitrogen.			
		In bread.	In undigested portion.	In digested portion.	Coefficient of digestibility.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
6001	White bread	2.04	0.06	1.98	97.06
6002	.....do	1.95	.06	1.89	96.92
6003	.....do	1.95	.20	1.75	89.72
6004	.....do	1.95	.20	1.75	89.72
6005	.....do	1.99	.13	1.86	93.47
6006	.....do	2.02	.13	1.89	93.57
6007	.....do	2.32	.17	2.15	92.67
6064	.....do	2.22	.15	2.07	93.25
6065	.....do	2.23	.15	2.08	93.29
6077	.....do	2.19	.15	2.04	93.15
6078	.....do	2.19	.14	2.05	93.62
6120	.....do	2.23	.15	2.08	93.27
	Average	2.11	.14	1.97	93.37
6047	Whole wheat bread	2.18	.17	2.01	92.20
6048	.....do	2.19	.18	2.01	91.67
6049	.....do	2.17	.17	2.00	92.15
6086	.....do	2.33	.23	2.10	90.13
6087	.....do	2.31	.20	2.11	91.34
	Average	2.24	.19	2.05	91.50
6034	Graham bread	2.11	.28	1.83	86.74
6035	.....do	2.08	.28	1.80	86.35
6036	.....do	2.09	.27	1.82	87.10
6037	.....do	2.03	.25	1.78	87.69
6097	.....do	1.91	.25	1.66	86.92
6098	.....do	1.98	.26	1.72	86.87
	Average	2.03	.27	1.77	86.94

COMPARISON OF COEFFICIENTS OF DIGESTIBILITY OF PROTEIN IN BREAD AS DETERMINED BY DIFFERENT METHODS.

Table 33 summarizes the results obtained by the different methods for determining the actual digestibility of the protein in different kinds of bread. In the column headed "artificial digestion" are the results obtained by digesting bread with pepsin in the manner just described. The figures in the column headed "natural digestion" show the coefficients of digestibility of the bread obtained in the experiments with

man, reported in Tables 4–27. In the following column are shown the results of the natural-digestion experiments when corrections are introduced, which were obtained by treating the feces with pepsin solution; and in the last column the results when corrections are introduced obtained by treating the feces with ether, alcohol, hot water, and lime-water. It will be remembered that the attempt was made to determine the metabolic products by these two methods and thus learn the actual, rather than the apparent, coefficients of digestibility of bread.

TABLE 33.—*Digestibility of nitrogen (or protein) of different kinds of bread as determined by different methods.*

Experiment number.	Kind of bread.	Laboratory number.	Artificial digestion.	Natural digestion.	Natural digestion, with correction obtained by pepsin method.	Natural digestion, with correction obtained by ether, alcohol, hot water, and limewater method.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
123	White bread	6001	96.85	90.87	96.21	92.60
124	.....do	6002	96.92	80.00	94.13	90.37
125	.....do	6003	89.72	81.68	90.74	85.74
126	.....do	6004	89.88	75.35	92.90	88.07
127	.....do	6005	93.47	79.61	90.55	84.49
128	.....do	6006	93.57	83.16	94.37	87.89
129	.....do	6007	92.67	88.18	95.80	92.50
130	.....do	6007	92.67	80.07	97.08	85.88
138	.....do	6064	93.25	94.51	98.47	96.39
139	.....do	6065	93.29	87.18	93.17	94.79
140	.....do	6077	93.15	92.22	97.80	94.77
141	.....do	6078	93.62	92.10	97.43	94.55
a146	.....do	6120	96.29	97.66	98.90	98.05
	Average	.....	93.26	85.41	94.72	90.67
135	Whole wheat bread	6047	92.20	79.15	96.35	84.58
136	.....do	6048	91.67	88.60	96.65	91.30
137	.....do	6049	92.15	86.27	95.95	90.83
142	.....do	6086	90.13	88.81	95.86	92.10
143	.....do	6087	91.34	90.35	96.33	93.05
	Average	.....	91.49	88.63	96.22	90.37
131	Graham bread	6034	86.74	77.54	90.93	82.22
132	.....do	6035	86.35	76.98	90.10	83.60
133	.....do	6036	87.10	79.34	93.95	85.48
134	.....do	6037	87.69	70.32	90.23	79.50
144	.....do	6097	86.92	80.66	92.22	86.92
145	.....do	6098	87.07	77.33	92.07	83.82
	Average	.....	86.97	77.02	91.58	83.88

a A period of partial fasting. This experiment not included in the average.

It will be seen that there are considerable differences in the values for the digestibility of the protein of bread as determined by the natural method when the corrections for metabolic products made according to the two ways are introduced. The values obtained by the use of the ether, alcohol, and limewater method give a much lower coefficient of digestibility than those obtained by correcting with the pepsin solution method. The coefficients of digestibility of the protein of white bread as obtained by artificial digestion agree quite nearly with those obtained by natural digestion when corrections are introduced obtained by determining the metabolic products in the feces by treatment with

a pepsin solution. On the other hand the coefficients of digestibility of the whole wheat bread as determined by artificial digestion accord more nearly with the results of natural digestion experiments when corrections are introduced obtained by determining the metabolic products by treatment with ether, alcohol, hot water, and limewater. With Graham bread the coefficients of digestibility obtained by artificial digestion are very nearly a mean between the results obtained by the natural digestion with suitable corrections introduced for metabolic nitrogen, as determined by the pepsin method and by the ether alcohol and limewater method.

The results thus far obtained are insufficient for general conclusions. They indicate, however, that none of the methods employed was entirely satisfactory. Experiments along the same line are now being carried on, and it is the author's intention to discuss the subject more fully when the results of these experiments are reported.

SKIM MILK VERSUS WATER IN BREAD MAKING.

At the dairy meeting of the Maine board of agriculture in 1897 a paper[1] was presented by one of the authors of this bulletin in which emphasis was laid upon the importance of skim milk as food. In discussing the value of this material the following statements were made:

The value of skim milk as food on the farm is not generally appreciated. Taken by itself, it is rather thin and, as people say, does not "stay by." The reason for this is simple; one has to drink a large quantity to get the needed nourishment, and further it is so readily disposed of that it does not satisfy the sense of hunger. But when eaten with bread, or used in cooking, it is a food material the value of which is not at all appreciated by the farmer. A pound of lean beef contains about 0.180 pound of flesh formers, and has a fuel value of 870 calories. Two quarts and a half, or 5 pounds, of skim milk will furnish the same amount of flesh formers, and have nearly the same fuel value as a pound of round steak. Two quarts of skim milk has 0.14 pound of flesh formers, and a fuel value of 680 calories, while this quantity of oysters contains only 0.12 pound of flesh formers, and a fuel value of 470 calories.

A few of the ways in which skim milk may be used in cooking are as follows: In the preparation of soups such as potato, celery, tomato, green pea, and green corn soups; fish, lobster, clam, and oyster chowders, bisque and stews, skim milk will equally well replace the whole milk that the directions for preparation usually call for. Skim milk makes as good white soup as whole milk. Bread mixed with skim milk is more nutritious than that made with water, while all kinds of quick biscuit, griddle cakes, etc., can be made with skim milk as well as with whole milk. In most kinds of cake skim milk will be found a perfect substitute for whole milk. If the skim milk is sour, so much the better for cake and quick bread making, as only half the cream of tartar called for in the recipe will be needed. Sweet skim milk can be used to advantage in making rice and Indian puddings, custards, squash and pumpkin pies, and the like, in the preparation of chocolate or cocoa as a drink, in the making of sherbets and other ices, and in dozens of other ways which will readily occur to housekeepers.

[1] Agriculture of Maine, 1897, p. 216.

In the above quotation the statement that bread baked from dough mixed with skim milk is more nutritious than that from dough mixed with water was based upon a knowledge of the composition of skim milk rather than upon exact experimental evidence, since at that time, so far as could be learned, no experiments on this subject had been reported. A short time ago the British Dairy Farmers' Association awarded prizes for bread made with skim milk instead of water. In a recent report of the society[1] the chemical composition of two samples of bread made with water and two made with skim milk were recorded. These were as follows:

TABLE 34.—*Composition of the dry matter of water bread and skim-milk bread.*

	Dry matter.	In dry matter.			
		Protein.	Fat.	Carbohydrates.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Water bread	60.64	12.05	0.20	87.27	0.48
Do	62.80	15.43	.29	82.37	1.91
Average	.....	13.74	.25	84.82	1.19
Skim-milk bread	61.36	14.98	.83	83.73	.46
Do	69.56	14.72	1.15	80.97	3.16
Average	.....	14.85	.99	82.35	1.81

There is nothing in the report to show that the same flour was used in the different samples, and indeed from the analyses it would seem as though this were not the case. It will be noticed that the protein in the second water bread was higher than in either of the skim-milk breads, and as is shown by the results of investigations reported beyond, this would hardly be true if the same kind of flour were used for both kinds of bread. The higher percentages of fat must be accounted for by the addition of shortening or by the milk being only partially skimmed.

Owing to a belief in the value of skim milk in bread making and to the lack of accurate information on the subject, three experiments were undertaken at the Maine Station. In each experiment four double loaves of bread were made from the same flour, two from dough mixed with water, and two from dough mixed with skim milk. The work was done by a practical bread maker, who used her own formulas, no conditions being imposed except that skim milk should be used in one case and water in the other. The quantities of the materials required were estimated, as is perhaps generally the case when bread is made in the household. They were weighed, however, before being used.

Table 35 shows the quantities of the ingredients used in the different experiments.

[1] Jour. British Dairy Farmers' Assn., 14 (1899), pt. 2, pp. 93–97.

TABLE 35.—*Weight of materials used in the different lots of bread.*

Ingredients.	Water bread.			Skim-milk bread.		
	No. 6115.	No. 6118.	No. 6190.	No. 6116.	No. 6119.	No. 6191.
	Grams (*a*)	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Flour	782	876	1,287	752	886	1,241
Salt	8	9	10	9	15	10
Sugar	31	24	25	26	26	25
Lard	14	21	15	10	23	15
Yeast	4	4	5	4	4	5

a One ounce equals 28.35 grams, or, in round numbers, 30 grams; 100 grams equals 3.5 ounces.

It will be seen that the amount of the flour and other ingredients varied within somewhat wide limits in the different experiments, but it is probable that the variation was not greater than in ordinary household practice.

The bread was mixed in the early evening and baked the next morning. On each occasion the skim-milk bread rose slowly, requiring two or three hours more than the other. The bread mixed with water gave a somewhat whiter and lighter loaf than that mixed with skim milk, but all the bread showed a fairly uniform texture, and doubtless would have been generally conceded to be of a high grade.

The loaves were cut up, dried at a temperature of 50° to 70° C., ground, and analyzed by the usual methods.[1] The results of the analyses are shown in Tables 36 and 37. In general the protein has been calculated throughout this bulletin by the use of the usual factor 6.25. It is probable, however, that the protein of bread is more nearly represented by nitrogen multiplied by 5.7.[2] Inasmuch, however, as the data recorded are more for comparison with each other than for comparison of actual quantities of protein, it makes little difference which factor is used. In Tables 36 and 37, however, the protein is estimated by the factor 5.7 as well as by 6.25, and two values are given for carbohydrates corresponding to the two values for protein.

TABLE 36.—*Composition of fresh substance of bread mixed with water and with skim milk.*

Laboratory number.	Kind of bread.	Water.	Protein.		Fat.	Carbohydrates.		Ash.	Heat of combustion.
			N × 6.25.	N × 5.7.		Taking protein as N×6.25.	Taking protein as N×5.7.		
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
6115	Water bread	40.40	8.97	8.09	1.13	48.59	49.47	0.91	2,683
6118	do	40.07	8.81	8.04	1.05	49.12	49.89	.95	2,704
6190	do	37.84	9.02	8.21	1.03	51.35	52.16	.76	.....
	Average	39.44	8.93	8.11	1.07	49.69	50.51	.87	.....
6116	Skim-milk bread	39.66	9.84	8.95	.75	48.58	49.47	1.17	2,668
6119	do	38.63	9.80	8.95	1.10	48.85	49.70	1.62	2,752
6191	do	35.62	10.29	9.35	.98	52.02	52.97	1.08	.....
	Average	37.97	9.98	9.09	.94	49.82	50.71	1.29	.....

[1] U. S. Dept. Agr., Division of Chemistry Bul. 46, revised.

[2] See discussion of this subject in U. S. Dept. Agr., Division of Chemistry Bul. 13, pt. 9, pp. 1171, 1192.

TABLE 37.—*Composition of water-free substance of bread mixed with water and with skim milk.*

Laboratory number.	Kind of bread.	Protein.		Fat.	Carbohydrates. [a]		Ash.	Heat of combustion.
		N × 6.25.	N × 5.7.		Taking protein as N × 6.25.	Taking protein as N × 5.7.		
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
6115	Water bread	15.05	13.74	1.90	81.52	82.83	1.53	4,502
6118	.....do	14.70	13.39	1.75	81.97	83.28	1.58	4,511
6190	.....do	14.50	13.22	1.67	82.60	83.88	1.23	.....
	Average	14.75	13.45	1.77	82.03	83.33	1.45	.....
6116	Skim-milk bread	16.31	14.88	1.25	80.50	81.93	1.94	4,423
6119	.....do	15.97	14.53	1.80	79.57	81.02	2.65	4,456
6191	.....do	15.97	14.53	1.21	81.13	82.57	1.69	.....
	Average	16.09	14.65	1.42	80.40	81.84	2.09	.....

[a] Assuming protein = N × 5.7.

By reference to the preceding tables it will be seen that the bread made with water contained slightly less dry matter than that made with skim milk. In the fresh bread there is but little difference in the content of carbohydrates, but as regards protein the bread from dough mixed with skim milk contains 1 per cent more than that from dough mixed with water. The difference in the protein content of the bread made in the two ways is still more noticeable when water-free substance is considered. Here there was 14.75 per cent of protein in the bread from dough mixed with water as compared with 16.08 per cent in that from dough mixed with skim milk.

THE DIGESTIBILITY IN PEPSIN SOLUTION OF BREAD MADE WITH SKIM MILK AND WITH WATER.

The only experiments upon the digestibility of bread made by use of skim milk which have come to our notice are those by Repsteiner and Spirig.[1] Two tests, each of three days' duration, were made. The diet consisted of skim-milk bread, butter, and tea. In the first experiment 1,780 grams of bread was consumed, containing 39.2 grams of nitrogen, 33 grams of fat, and 1,098 grams of carbohydrates. The feces contained 53 grams of dry matter, with 2.3 grams of nitrogen and 4.7 grams of fat. In the second experiment 1,533 grams of dry matter in the form of bread was eaten. This contained 343 grams of nitrogen, 267 grams of fat, and 961 grams of carbohydrates. There was excreted in the feces 59 grams of dry matter, containing 3.8 grams of nitrogen and 8.7 grams of fat. No estimate of the amount of carbohydrates in the feces is given.

According to these results (as usually estimated) about 96.5 per cent of the nitrogen and 95 per cent of the fat were assimilated, values which are lower than those obtained in our experiments with bread in a mixed diet. However, as has been previously noted (see p. 15), there

[1] Korbl. Schweiz. Aerzte, 25, pp. 705–710.

appears to be considerable difference between the digestibility of bread when eaten alone and when eaten in combination with other food.

For the purpose of studying the relative digestibility of the protein in breads made with skim milk and with water, artificial digestion experiments were carried on by the authors, using a pepsin solution in the manner previously described. As will be seen, no particular difference in the digestibility of the protein of the two kinds of bread was found by the method followed. The results obtained were as follows:

TABLE 38.—*Digestibility of the protein of water bread and skim-milk bread in pepsin solution.*

Laboratory number.	Kind of bread.	Coefficients of digestibility.
		Per cent.
6115	Water bread	95.62
6118	.....do	93.79
6190	.....do	96.53
	Average	95.31
6116	Skim-milk bread	94.32
6119	.....do	94.10
6191	.....do	96.25
	Average	94.89

The experiments here reported upon the composition and digestibility of skim-milk bread are not sufficient in extent to serve as a basis for definite conclusions. They do, however, appear to substantiate the opinion expressed by the authors, that skim-milk bread contains more protein than water bread. As regards the digestibility of the two there seems to be little difference. Therefore, other things being equal, it appears that the body would obtain more digestible protein from bread containing the larger amount, i. e., from skim-milk bread.

The practice of using skim milk in the making of bread is said to be quite prevalent in some sections. That the custom does not become more general must be due to a lack of appreciation of the food value of skim milk.

LOSSES IN BREAD MAKING.

Several experiments have been carried on in connection with investigations made in cooperation with the United States Department of Agriculture upon the loss of materials in bread making.[1] The following experiment was made in order to compare the losses in making bread by the use of skim milk and by the use of water in the preparation of the dough. All the materials used and the bread made were weighed and analyzed. It is thus possible to calculate the sum of

[1] U. S. Dept. Agr., Office of Experiment Stations Buls. 35, 52, and 67.

nutrients in the various ingredients of the dough, and compare this amount with the total amount of nutrients found in the baked breads. The composition of the different materials used is shown in the following table:

TABLE 39.—*Composition of materials used in making bread.*

Laboratory number.	Materials.	Water.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion determined.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
6113	Flour	12.45	13.44	1.36	72.18	0.57	.....
6189	.....do	11.70	13.31	1.44	73.05	.50	.....
6114	Skim milk	89.16	3.75	.40	5.92	.77	515
6117	.....do	90.29	3.63	.12	5.30	.66	454
6188	.....do	90.29	3.88	.36	4.68	.79	469
	Yeast	65.10	11.70	.40	21.00	1.80	625

Three comparisons of the loss of nutrients in mixing bread with water and with skim milk were made. In each case the flour, salt, sugar, lard, and yeast used in the two sorts of bread were the same. The only variation was in the liquid used to mix the dough. The amount of the several materials used, the weight of the resulting bread, and the total quantity of the several nutrients in the different ingredients and in the resulting bread are shown in the following table:

TABLE 40.—*Weights and total nutrients of materials used and of bread made.*

	Weight of ingredients.	Total dry matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
Water bread No. 6115:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
Flour No. 6113	782.4	684.99	105.15	10.64	564.74	4.46	3,074.0
Salt	8.3	8.30	.....	.....	.....	8.30	.....
Sugar	31.2	31.20	.....	.....	31.20	.....	122.3
Lard	14.0	14.00	.....	14.00	.....	.....	133.2
Yeast	4.4	1.53	.51	.02	.92	.08	2.8
Total	.....	740.02	105.66	24.66	596.86	12.84	3,332.3
Bread	1,164.0	693.67	104.41	13.15	565.52	10.59	3,122.8
Losses	.....	46.35	1.25	11.51	31.34	2.25	209.5
Skim-milk bread No. 6116:							
Flour No. 6113	752.4	658.72	101.12	10.22	543.09	4.29	2,956.2
Salt	9.4	9.40	.....	.....	.....	9.40	.....
Sugar	26.0	26.00	.....	.....	26.00	.....	101.9
Lard	9.6	9.60	.....	9.60	.....	.....	91.3
Yeast	3.6	1.26	.42	.01	.76	.07	2.3
Milk No. 6114	523.0	56.70	19.61	2.09	30.97	4.03	269.3
Total	.....	761.68	121.15	21.92	600.82	17.79	3,421.0
Bread	1,210.8	730.56	119.16	9.14	588.08	14.18	3,230.9
Losses	.....	31.12	1.99	12.78	12.74	3.61	190.1
Water bread No. 6118:							
Flour No. 6113	876.0	766.94	117.74	11.91	632.30	4.99	3,441.8
Salt	9.0	9.00	.....	.....	.....	9.00	.....
Sugar	24.4	24.40	.....	.....	24.40	.....	95.7
Lard	20.8	20.80	.....	20.80	.....	.....	197.8
Yeast	4.4	1.53	.51	.02	.92	.08	2.8
Total	.....	822.67	118.25	32.73	657.62	14.07	3,738.1
Bread	1,322.6	792.50	116.53	13.84	649.64	12.49	3,475.2
Losses	.....	30.17	1.72	18.89	7.98	1.58	262.9
Skim-milk bread No. 6119:							
Flour No. 6113	886.4	776.04	119.13	12.06	639.80	5.05	3,482.7
Salt	15.0	15.00	.....	.....	.....	15.00	.....
Sugar	25.8	25.80	.....	.....	25.80	.....	101.2
Lard	23.2	23.20	.....	23.20	.....	.....	220.7
Yeast	3.9	1.37	.46	.02	.82	.07	2.4
Milk No. 6117	575.3	55.69	20.88	.69	30.32	3.80	261.1
Total	.....	897.10	140.47	35.97	696.74	23.92	4,068.1
Bread	1,426.0	874.30	139.66	15.77	695.69	23.18	3,924.3
Losses	.....	22.80	.81	20.20	1.05	.74	143.8

TABLE 40.—*Weights and total nutrients of materials used and of bread made*—Cont'd.

	Weight of ingredients.	Total dry matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion.
Water bread No. 6190:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
Flour No. 6189	1,287.3	1,136.60	171.33	18.54	940.30	6.44	5,098.6
Salt	10.0	10.00	.....	.....	.....	10.00	.....
Sugar	250.9	25.00	.....	.....	25.00	.....	98.0
Lard	15.0	15.00	.....	15.00	.....	.....	142.7
Yeast	5.0	1.75	.59	.02	1.05	.09	3.1
Total	.....	1,188.35	171.92	33.56	966.35	16.53	5,342.4
Bread	1,864.0	1,158.60	168.12	19.19	957.13	14.16	5,172.6
Losses	.....	29.75	3.80	14.37	9.22	2.37	169.8
Milk bread No. 6191:							
Flour No. 6189	1,240.6	1,095.45	165.12	17.86	906.27	6.20	4,914.0
Salt	10.0	10.00	.....	.....	.....	10.00	.....
Sugar	25.0	25.00	.....	.....	25.00	.....	98.0
Lard	15.0	15.00	.....	15.00	.....	.....	142.7
Yeast	5.0	1.75	.59	.02	1.05	.09	3.1
Milk No. 6188	800.0	77.68	31.04	2.88	37.44	6.32	375.2
Total	.....	1,224.88	196.75	35.76	969.76	22.61	5,533.0
Bread	1,870.0	1,203.80	192.44	18.34	972.81	20.21	5,402.4
Losses	.....	21.08	4.31	17.42	*a*3.05	2.40	130.6

a Gain.

It will be seen that in each case there was a loss of dry matter in the baking. This loss falls chiefly upon the fats and carbohydrates. The loss of carbohydrates may be readily understood, since they furnish food for the yeast plant, being in part converted into carbonic-acid gas and alcohol, in which form they are expanded by the heat of cooking. The loss of fat is not so readily explained. In fact, it is not improbable that this loss is not so large as it appears to be, but that in the process of bread making the starch and dextrin so inclose the fat that it is not removed by the usual extraction with ether.[1] Other explanations have been suggested.[2] That there is a small loss of fat is indicated, however, by a slightly greater loss of energy than would be accounted for by the loss of carbohydrates, as is pointed out by Voorhees.[3]

The results agree in the main with those previously reported by other investigators, and are here given for the purpose of placing the results thus far obtained upon record. It is expected that these, as well as most of the other data reported in this bulletin, can be combined later with the results of other work now in progress for more complete discussion.

[1] Weibull, Experiment Station Record, 5 (1894), p. 520. Also Voorhees, U. S. Dept. Agr., Office of Experiment Stations Bul. 35.

[2] See the discussion on this subject in U. S. Dept. Agr., Office of Experiment Stations Bul. 67.

[3] U. S. Dept. Agr., Office of Experiment Stations Bul. 35, p. 17.

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